SAFE STORAGE OF FABA BEAN USING LASER AND ULTRAVIOLET TECHNIQUES

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ABSTRACT

The main purpose of this study was to investigate the effects of laser and Ultraviolet irradiation on faba bean seed quality by studying the physical, mechanical, chemical, biological and optical properties of faba bean during storage periods. A laser light source was Helium-Neon laser with a wavelength 632.8nm and power of 8mW. Three exposure time of laser irradiation were of 15, 30, and 45min and 0min for treatment without irradiation were used on the Faba bean Giza 716 variety. A UVC source was 253.7 nm of wavelength and 36 watts of the power. Three irradiation times of UVC investigated were of 30, 60, and 90 min of exposure times were used, also and 0min for treatment without irradiation, After seed irradiation, they were stored for nine months and then four samples were taken from each treatment every three months and determined the chemical, physical, mechanical, biological and optical properties to observe the changes that occur in faba bean seeds during the storage period. The obtained result showed that the main dimensions, mass and bulk volume, true volume, protein, moisture content, fat, fiber, L and b* parameter were decreased by decreasing laser exposure time and UVC irradiation times and increasing the storage period. Meanwhile, the bulk, true density, shear force, penetration force, ash percentage, carbohydrate percentage, a* parameter and total count were increased by increasing the storage period and decreasing laser exposure time and UVC irradiation times. Those techniques extend the shelf-life of the faba bean grains, reduce the loss of faba bean grains during the storage period of nine months and use the laser and UV techniques as a clean source without pesticide, which leads to keep the storage environment without any pollution. Our findings suggest that exposure for laser and UV may favour external treatment with particulars by light environment, to preserve faba bean seeds with high-quality.

LIST OF CONTENTS

LIST OF FIGURE

figures **page**

LIST OF TABLES

ABBREVIATIONS

Symbols	Nomenclatures
UV	Ultraviolet
laser	Light Amplification by Stimulated Emission of Radiation
FAO	United Nations Food and Agriculture Organization
RH	Relative Humidity
He-Ne	Helium-Neon laser
MC	Moisture Content
UVA	Region covers the wavelength range 315-400 nm
UVB	Region covers the wavelength range 280-315 nm
UVC	Region covers the wavelength range 100-280 nm
LED	Light-Emitting Diodes
RGB	Red-Green-Blue (color model based on additive color primaries)
HSI	Hue, Saturation and Intensity
IA	Image Analysis

1. INTRODUCTION

1. INTRODUCTION

Faba bean (*Vicia faba L.*) is grown worldwide in cropping systems as a grain (pulse) and green-manure legume. The faba bean contributes to the sustainability of cropping systems via its ability to contribute nitrogen (N) to the system via biological N_2 fixation, faba bean reduced fossil energy consumption in plant production, and it provides food and feed rich in protein.

Food irradiation is a technology that improves the safety and extends the shelf life of foods by reducing or eliminating microorganisms and insects.

Hasanuzzaman (2015) defined seed quality as varietal pure with a high germination percentage, free from disease and disease organisms, and with proper moisture content and weight. Quality seed ensures good germination, rapid emergence, and vigorous growth. These aspects translate to a good stand (whether greenhouse or field). Poor quality seed results in "skips," excessive thinning, or yield reductions due to overcrowding, all of which diminish profitability.

Storage may be defined as the preservation of viable seeds from the time of collection until they are required for sowing. When seed for crops can be sown immediately after collection, no storage is needed.

Youseif et al. (2016) said that faba bean (Vicia faba L.) is one of the oldest legume crops grown in Egypt. However, production has declined considerably from 523,000 tonnes in 1998 to 158,000 tonnes in 2014-often a result of susceptibility to foliar diseases, the effects of parasites, and/or competition with other crops. Egypt now is the world's largest importer of faba bean; its annual requirement of half-million tonnes accounts for over half of global imports. Therefore, increasing faba bean production and improving yield quality is a major target to meet the demand of the increasing Egyptian population since faba bean constitutes a major part of the diet of the Egyptians.

(The sustainable agricultural development strategy 2030) stated that the main goal of developing leguminous crops by increasing cultivated areas and improving productivity levels to achieve a high percentage of self-sufficiency as one of the lowest percentages after the group of self-cultivated crops. Increasing the area of faba beans from about 202,000 fed currently to a 400,000 fed acre in 2030, as well as improving productivity to reach 1.8 instead of 1.42 tons per fed currently, to reach the targeted production to 720,000 tons in 2030

Karthikeyan et al. (2009) the protection of stored agricultural products against insect attack is essential for a safe and steady supply of high-quality food. Insect damage in stored grains and pulses may amount to

10-40%. In the past, insect infestation has been often a less serious problem because farmers cultivated traditional varieties, which, although low yielding, were more resistant to attack by insects. However, the introduction of high yielding varieties has resulted in increased storage losses, as these varieties are usually susceptible to insect damage. Hence, the storage of grains and seeds without pest infestation is essential. Indigenous practices have advantages over outside knowledge; it has little and no cost and is readily available.

Parimala et al. (2013) reported that nearly 30% of legumes, grains and seeds are being lost during handling and the post harvest process which includes (transport, storage, and packing) due to insects, diseases, rodents and microorganisms. That processing period begins right at the time of attainment of the physiological maturity of seeds in the field until it was planted in the next season. Care should be taken to preserve the germination capacity, viability and vigour of the seeds.

Prabhu and Rajeswari (2017) Faba bean (*Vicia faba*), a legume with medicinal properties, it is alimentally affluent with carbohydrates, proteins, lipids and other micronutrients. It additionally contains anti-alimental compounds such as vicine and covicine and its role in favism have been discovered, and it is enriched with antioxidant properties and plays a potent role against diseases such as colon cancer, diabetes mellitus. Faba bean came in the first order than other pulse crops as a main source of protein for a large sector of the Egyptians

AlSalhi et al. (2018) state that laser irradiation of seeds can increase the growth rate, productivity, root length, height, etc. These changes strongly depend on the type, wavelength, and intensity of laser radiation.

Hidaka and Kubota (2006) pointed out that the aim of using UV sterilization was to control microorganisms that cause grain degradation, as a method that is eco-friendly and safe for storage without the need for postharvest application.

Grain quality is at its highest when first loaded into storage, but can steadily deteriorate if the storage environment is not well managed. A combination of good farm hygiene, storage choice and aeration cooling are important for maintaining grain quality and overcoming many pest problems associated with storage. So it was necessary to use techniques to extend the shelf-life of faba bean, reduce the losses of seeds during the storage period

The objectives of this study are,

- Study the physical, mechanical and chemical properties of faba bean during the storage period.

- Using lasers and UV rays to conserve faba bean during the storage period.

- Determine the most suitable dose of laser and UV radiation to conserve the faba bean during storage.

- Statistic analysis of the techniques used.

- Studying quality evaluation of faba bean during the storage period.

- Determining color changes for faba bean according to irradiation by lasers and UV rays during the storage period.

2. LITRATURE REVIEW

2. LITERATURE REVIEW

2.1. Legumes Seeds:

2.1.1. Legumes Seeds important:

Graham and Vance (2002) said that legumes play a critical role in natural ecosystems, agriculture, and agroforestry, where their ability to fix N in symbiosis makes them excellent colonizers of low-N environments, and economic and environmentally friendly crop, pasture, and tree species. Legume unfortunately yields, continue to lag behind those of cereals.

Alghamdi (2009) stated that the Legume seeds contain several comparatively minor proteins, including trypsin inhibitors, lectins, lipoxygenase and urease, which are relevant to the nutritional quality of the seed.

Silva and Peix (2010) summarized that Legumes may be produced sustainably for their ability to fix atmospheric nitrogen in symbiosis with a group of bacteria called rhizobia. In the development of this symbiosis, legume flavonoids play a fundamental role, being excreted by the plant in response to nodulation factors produced by the bacteria. Are flavones, which are molecules, mainly found in legumes, may have beneficial effects on human health, and their use can be helpful in the fight against many diseases, including several types of cancer and cardiovascular disorders.

College Board (2011) explained that symbiotic bacteria, such as Rhizobium are found in the roots of legumes and provide a direct source of ammonia for the plants. In root nodules of these legumes, the bacteria split molecular nitrogen into two free nitrogen atoms, which combine with hydrogen to form ammonia (NH_3). These plants are common examples of legumes: clover, alfalfa, soybeans, and chickpeas.

Jager (2013) stated that grain legumes provide about 350 kcal per 100 g edible portion, which is similar to the amount of energy provided by most staple foods, such as maize. However, groundnut and soybean provide more energy per 100 g edible portion because of their higher content of fat (45.9, 15.9g) than other grain legumes.

Annor et al. (2014) mention that legumes have a special place in the diet of humans because they contain nearly 2–3 times more protein than cereals. Legumes are also excellent sources of complex carbohydrates and have been reported as beneficial for cardiovascular diseases and diabetes by some researchers, probably due to the large amounts of water-soluble fiber and a large content of phenolics.

Ade-Omowaye et al. (2015) reported that legumes demonstrated their ability to help manage both cholesterol and blood glucose. Legume consumption has been associated with a lower risk of developing several chronic diseases, mainly cardiovascular diseases, but also obesity and type 2 diabetes.

Nambi et al. (2017) mentioned that legumes (poor man's meat) play an important role in human nutrition since they are rich in protein, calories, minerals and vitamins and therefore can be good supplements.

2.1.2. Legumes Seeds production:

Graham and Vance (2002) reported that a research orientation that better balances the needs of third-world or sustainability oriented agriculture with the breakthrough technologies of genomics and bioinformatics is needed. It requires stronger and more adventurous breeding programs, better use of marker-assisted technologies, and emphasis on disease resistance, enhanced N fixation, and tolerance to edaphic soil constraints. It also requires an extension of existing low-cost technologies, such as rhizobial inoculation, to the small farmer.

Silva and Peix (2010) summarized that the leguminosae are the third largest flowering plant family and includes more than 19,000 species, a small part of them considered edible for man and animals. Grain legumes such as soybean, chickpea, pea, lentil, common bean, Faba bean or peanut are the main protein source together with cereals in many developing countries. They also form part of the Mediterranean diet and some of them are consumed after microbial fermentation as probiotics.

College Board (2011) explained that the breakdown of these legumes by bacteria during ammonification returns excess nitrogen not use by the plant to the surrounding soil. Therefore, to promote sustainable soil fertility, it is beneficial to use these agricultural crops in rotation with other plants, such as corn, that are more profitable but deplete the available nitrogen in the soil-Some free-living aerobic bacteria, such as Azotobacter, and anaerobic bacteria, like Clostridium, freely fix nitrogen in the soil and in aquatic environments. Some members of the photosynthetic Cyanobacteria phylum fix nitrogen in aquatic environments as well.

Nedumaran et al. (2015) stated that since 1980, the global production of all the grain legume crops, namely chickpea, pigeon pea, cowpea, dry bean, faba bean, lentil, soybean and groundnut, has increased at the rate of more than 1% per annum. Globally, soybean, faba bean, and groundnut have the highest yields, ranging between 1.5 and 2.4 tons/ha.

2.1.3. Nutrient characteristics of Legumes:

Gajzágó (2004) pointed that Legumes are a rich source of nutrients such as protein, starch, minerals and vitamins and have also important health protective compounds (phenolics, inositol phosphates and oligosaccharides).

Because of the advantageous composition of legume seeds, they can be used not only as meat replacers but also as components of rational nourishment and food for vegetarians. The isolated proteins, starch and fibers from legume seeds have good physico-chemical and health protecting properties and are promising basic materials for food industrial use.

Annor et al. (2014) mention that legumes are also a good source of vitamins (thiamine, riboflavin, niacin, vitamin B6, and folic acid) and certain minerals (Ca, Fe, Cu, Zn, P, K, and Mg), and are an excellent source of polyunsaturated fatty acids (linoleic and linolenic acids). Indeed, several studies suggest that increased consumption of legumes may protect against diseases such as cancer, diabetes, osteoporosis, and cardiovascular diseases, among others.

Table (2-1): show the nutrient analysis of faba bean, Row, mature seeds per 100g

Principle	Nutrient value
Energy	341kcal
Carbohydrates	58.59g
Protein	26.12g
Total fat	1.53g
Cholesterol	0mg
Dietary fiber	25g
Vitamins	
Folates	423 µg
Niacin	2.832mg
Pantothenic acid	0.976mg
Pyridoxine	0.366mg
Riboflavin	0.333mg
Thiamin	0.555mg
Vitamin A	53IU
Vitamin C	1.4mg
Vitamin K	9µg
Electrolytes	
Sodium	13mg
Potassium	1062mg
Minerals	
Calcium	103mg
Copper	0.824µg
Iron	6.70mg
Magnesium	192mg
Manganese	1.626mg
Phosphorus	421mg
Selenium	8.2µg
Zinc	3.14mg
Phytonutrients	
Carotene - ß	32µg
Carotene - α	0µg
Lutein - zeaxanthin	0µg

Source: USDA National Nutrient database.

Rebello et al. (2014) mention that legumes contain important vitamins and minerals as well as a host of other bioactive substances including phytochemicals that limit the free radical-mediated cellular signaling, and inflammation to mitigate carcinogenic processes as well as adverse cardiovascular events. Thus, legume consumption may be recommended in the prevention and management of obesity and chronic diseases, including diabetes and cardiovascular disease.

Ade-Omowaye et al. (2015) reported that the nutritional value of legumes is gaining considerable interest globally because of the demand for healthy foods. Consumed regularly, legumes contribute to a healthy diet and would help control metabolic diseases such as diabetes mellitus legumes are affordable source of protein and have the advantage of having a low glycemic index, and significant antioxidant activity.

2.2. Faba Beans Crop:

Darwish and Abdalla (1997) stated that faba bean used for human consumption, animal feeding, and industry. Etc. The importance of faba bean in Egypt lies not only due to its multiple uses in preparing diverse local dishes, but also due to its important role in crop rotation. Thus, faba bean is a highly esteemed crop by the Egyptians.

Altuntas and Yıldız (2007) pointed out that faba bean consumed as fresh faba bean, dried faba bean and conservative of faba bean. It uses as a medicinal drug for stones, kidney, liver malfunctioning an eye disease. Simultaneously, they used for animal food. Broken grains were mixed into animal diet and vegetative parts of the plant used for the litter in animal house.

Sing et al. (2013) mention that faba bean being incredible and crop complete food, unfortunately, some part of world, including India, it is still underutilized crop and not fully exploited so far, though it is seen as an agronomically viable alternative crop to cereal, with a potential of fixing free nitrogen up to 300 kg N ha- It is a good source of lysine-rich protein and good source of levodopa (L-dopa), a precursor of dopamine, can be potentially used as medicine for treating Parkinson’s disease.

Hegab et at. (2014) mentioned that faba bean (*Vicia faba L.,*) is considered one of the most important legumes in Egypt. It has become one of the strategic crops due to its income to the farmers. Also, it’s important for soil fertility, human nutrition as a good source of vegetarivegetarian protein animal feeding and industrial purposes.

ICARDA (2018) reported that new faba bean varieties released in Egypt are successfully resisting debilitating diseases and helping the country regain its position as one of the most important global producers of faba bean. Over the past decade, the production has declined considerably – often a result of susceptibility to foliar diseases, the effects of parasites such as orobanche, and competition with other crops, notably sugar beet and fruit trees.

2.2.1. Faba bean cultivated:

Bakry et al. (2011) stated that faba bean (*Vicia faba L.*) plays an essential role in enhancing soil fertility. Also, production of faba bean in Egypt is still limited and falls to face the increasing local consumption of the crop, this is related to the cultivated area by faba bean in Egypt is relatively small and decreased dramatically in the last decade. This is due to the strong competition between faba bean and other strategic winter season crops such as wheat and clover on limited arable land the Nile valley and Delta. Faba bean production is affected by different factors such as climatic conditions, soil fertility, water supply, varieties or genotypes and plant population density.

Gnanasambandam et al. (2012) summarized that breeding methods that are applicable to self-pollinated crops or open-pollinated crops are not highly suitable for faba bean. However, traditional breeding methods such as recurrent mass selection have been established in faba bean and used successfully in breeding for resistance to diseases.

Molecular breeding strategies that integrate the latest innovations in genetics and genomics with traditional breeding strategies have many potential applications for future faba bean cultivar development.

2.2.2. Faba bean production:-

Darwish and Abdalla (1997) stated that wide variation for faba beans acreage and production could be observed. One of the drawbacks affecting this crop is its yield instability. This is attributed to various biotic and abiotic limitations. These limitations include diseases, pests, Orobanche and less favourable environments. Etc. faba bean plants are attacked by both foliar diseases and seedling root diseases. Foliar diseases, i.e. leaf spots (by Botrytis sp., Stemphylium botryosum and Altenaria tenuis) and rust (by Uromyces faba) are the limiting factors for faba bean production in the northern parts of Egypt.

Sing et al. (2013) mentioned that faba bean (*Vicia faba L.*) is among the oldest crops in the world. Globally, it is the third most important feed grain legume. Currently, 58 countries produce this bean on a large scale. Probably, faba beans are one of the best-performing crops under global warming and climate change scenarios because of its unique ability to excel under all most types of climatic conditions coupled with its wide adaptability to the range of soil environment.

Hegab et at. (2014) mentioned that increasing faba bean production and improved yield, quality is the major target to meet the demand of the increasing Egyptian population since faba bean constitutes a major part of the diet of the Egyptians. Sowing date and irrigation regimes are playing an important role in water utilized and consequently on yield and quality of faba bean seeds.

Negash et al. (2015) mentioned that according to the United Nations Food and Agriculture Organization (FAO, 2014), China is currently the world's leading producer, accounting for approximately 60% of the total. Other important production regions are northern Europe, the Mediterranean, the Nile Valley, Ethiopia, Central and East Asia, Oceania and the Americas.

Buraka et al. (2016) stated that faba bean (Vicia faba L.) has a long tradition of cultivation in Old World agriculture, being among the most ancient plants in cultivation and among the easiest to grow. Along with lentils, peas, and chickpeas, they are believed to have become part of the eastern Mediterranean diet around 6000 BC or earlier. They are still often grown as a cover crop prevents erosion, because they can overwinter and because as a legume, they fix nitrogen in the soil.

Ehsanzamir (2018) stated that the world production of faba beans was 4.3 million tons in 2010 compared to soybean's 262 million and pea's 10 million tons. Faba beans are cultivated in more than 50 countries with China as its largest producer. Due to its high protein content, it is used today as both human food and feed for cattle. Most varieties contain tannins thus making it unsuitable as feed for mono-gastric animals and must be preheated before human consumption.

ICARDA (2018) reported that Egypt now satisfies around 70% of its demand through imports. To maximize production, the improved varieties are introduced alongside a package of inputs and recommended techniques, including conservation agriculture; optimum fertilizer application rates; the application of seeds at a rate of 30 kg/fed, rather than the more conventional 50-70 kg/fed; and ideal irrigation schedules that effectively exploit growing stages and rainfall to achieve water savings. Farmers are also encouraged to practice early sowing – mid-October to early-November – and apply fertilizer through drip irrigation to strengthen faba bean resistance to foliar diseases like chocolate spot.

2.2.3. Nutrient characteristics of Faba bean:

Gajzágó (2004) stated that legumes are relatively rich sources of protein as the seeds contain 200-250 g protein/kg. The protein content of cooked legume seed (70-100 g/kg cooked food) is similar to that of bread (80-90 g/kg), but still much higher than for potato (15-22 g/kg). Legume seeds are rich in lysine and poorer in sulfur-containing amino acids (methionine and cysteine) compared to cereals. Lysine is the first limiting amino acid, so legumes must complement cereals in lysine balance. Legume proteins are composed of several thousand specific proteins. About 70 to 80 % of the crude protein in legume seeds is storage protein. The non-storage proteins are enzymes, enzyme inhibitors, hormones, transporting, structural and recognition proteins.

Alghamdi (2009) stated that the nutritional value of faba bean has always been traditionally attributed to its high protein content, which ranges from (27-34%); depend on genotypes. Most of these proteins comprise globulins (79%), albumins (7%) and glutelins (6%).

Khattab et al. (2009) and Mahe et al. (1994) stated that plant proteins provide nearly 65% of the world protein supply for humans with 45–50% from cereals and legumes. Among plants, legumes are considered the major source of dietary proteins ranging from 20 to as much as 40 g/100 g dry matter.

Gnanasambandam et al. (2012) summarized that faba bean (*Vicia faba L.*) is a major food and feed legume because of the high nutritional value of its seeds. The main objectives of faba bean breeding are to improve yield, disease resistance, abiotic stress tolerance, seed quality and other agronomic traits. The partial cross-pollinated nature of faba bean introduces both challenges and opportunities for population development and breeding.

Hashemabadi (2013) stated that broad bean (*Vicia faba L.*) is consumed worldwide as protein sources by humans. Faba bean grains have about 23% protein based on dry matter, which is considered among vegetables. Vicia faba L., Fabaceae, can fix nitrogen and it is used in crop rotation. Like other members of Fabaceae, Vicia faba also increases the humus of soil. Depending on plant density and field management, this plant can fix nitrogen up to 40 kg ha-1 annually.

El-Mergawi and Tale (2014) pointed out that faba bean (*Vicia faba L.*) is the most cultivated leguminous species in the world. Legumes are an important component of traditional diets of several regions worldwide, as they are low in fat, rich in protein, dietary fiber and various micronutrients and phytochemicals. Egypt is one of the largest consumers of pulses in the world.

Turco et al. (2016) mentioned that recent papers suggest that Faba bean and derivatives could represent a suitable food in the treatment of diabetics, in hypertension and help prevent cardiovascular disease.

Among bioactive molecules involved in the molecular mechanisms, which contribute to the prevention of chronic degenerative disease, a key role is exerted by plant polyphenols.

Ehsanzamir (2018) stated that commercial faba bean grain has a protein content of 24- 30%, depending on the variety. Just like other legumes, faba beans accumulate several proteins during seed development. The amino acid compositions of the protein in faba beans are similar to other legumes and are characterized by a generally good nutritional quality, except for low sulphur amino acid and tryptophan concentration. In a diet, it is easily compensated for by eating it with grains.

2.2.4. Properties of faba bean:

Fasina et al. (2001) reported that five legume seeds (kidney beans, green peas, black beans, lentils and pinto beans) were heated by infrared to surface temperature of 140°C. The changes in chemical composition, physical surface temperature of 140 mechanical and functional properties of the processed seeds were measured and compared to those of the raw seeds. Significant changes in the properties of the seeds in terms of increased volume, lower rupture point and toughness, higher water uptake and higher leaching losses (when the seeds were soaked in water) were obtained. The changes in the physical and mechanical properties were attributed to possible cracking of the seed. Even though trypsin inhibitor activity was reduced, infrared heating did not significantly affect the starch and protein components of the seeds. The functional characteristics of flour from the infrared-heated seeds were superior to those of flour from untreated seeds.

Altuntas and Yıldız (2007) determined the effect of MC on some physical properties and mechanical behavior under compression load of faba bean grains. The average length, width, thickness, geometric mean diameter, the unit mass of grain, sphericity, thousand grain mass, the grain volume, the true density, porosity and surface area and the angle of repose were increased as the MC increased. Meanwhile, the bulk density decreased with an increase in the moisture content. The static and dynamic coefficients of friction on various surfaces, namely, galvanized metal, chipboard, mild steel, plywood and rubber also increased linearly with an increase in moisture content. Specific deformation and rupture energy of the faba bean grains increased in magnitude with an increase in moisture content.

Altuntas and Demirtola (2007) studied the effect of MC on physical properties of some grain legumes seeds such as kidney bean

(Phaselous vulgaris), dry pea (Pisum sativum), and black - eyed pea (Vigna sinensis) seeds. The sphericity, thousand - seed mass (1000 - seed mass), and projected area increased, whereas the bulk and kernel densities linearly decreased with an increase in the MC for each grain legume seed. The porosity, the volume of seed, and angle of repose increased for three grain legumes seeds, whereas the angle of repose decreased for black - eyed pea seeds in the moisture contents studied. The static and dynamic coefficients of friction on various surfaces, namely, galvanised metal, chipboard, mild steel, plywood, and rubber also linearly increased with an increase in MC of each grain legume seed.

Gursoy and Guzel (2010) pointed out that physical and aerodynamic properties of agricultural products are needed in design and adjustment of machines used during harvesting, separating, cleaning, handling and storing of agricultural materials and convert them into food, feed and fodder. The properties which are useful during design must be known and these properties must be determined at laboratory conditions.

Dobrzański and Stępniewski (2016) explained that the physical properties of seeds and grain is a wide knowledge that can be useful in the farming, harvesting and storage or in processing such as drying, freezing and other. This knowledge is important in the design of machinery to harvest and in preparation of the processing chain from grain to food. Accurate design of machines and processes in the food chain from harvest to table requires an understanding of the physical properties of raw material. Considering either bulk or individual units of the agricultural material, it is important to have an accurate estimation of shape, size, volume, density, specific gravity, surface area, and other mechanical characteristics, which may be considered design parameters for food production. The measurement techniques allow computation of these parameters, which can then provide information about the effects of processing. Some characteristics, such as color, mechanical parameters, rheological properties, thermal and electrical resistance, water content and other physical quantities, give an excellent description of product quality.

Venkatachalam and Ilamurugu (2011) explained that this phenomenon can be accounted for by the fact that fats and oils do not mix with water. Thus, in a seed with 50% oil content, the moisture has to be concentrated in half the seed, while in a seed containing 10% oil, the moisture is distributed throughout 90% of the seed. Thus the maintenance of MC of seed during storage is a function of Relative humidity (RH) and to a lesser extent of temperature. At equilibrium MC there is no net gain or loss in seed MC when the seed is placed in a new environment with RH higher or lower than that of the seed, the seed will gain or lose moisture till it reaches new equilibrium MC at this particular new environment.

2.2.5. Faba bean germination

Brownfield (2006) stated that the type of vigor test selected will depend on the species to be evaluated. Update testing for germination and vigor is highly recommended, with a six-month cycle being the most common. However, the seed enhanced with processes such as priming may require more frequent monitoring to ensure that seed quality is being maintained.

Abu-Elsaoud et al. (2008) found that IR laser enhanced the germination percentage of wheat cultivars after 3 days to reach a maximum of 93.3%3 in cultivar akcay after irradiation for 1200 sec. An IR-irradiation of 30 sec caused a general inhibition in germination in the four cultivars under study with a minimum germination percentage of 6.7% recorded in sakha-168. Germination percentages at 5 and 7 days showed similar behavior with a maximum germination percentage mainly recorded at 30 sec of infra-red seed irradiation. So, seed pre-sowing irradiation with IR laser one-shot for

1 sec is recommended to be enough to enhance the germination percentage of experiments wheat studied.

Lumme et al. (2008) summarized that terrestrial laser scanning is a useful tool for growth height and grain yield estimation. Growth height of cereal plants was easy to estimate using laser scanner data and estimated results correlate with tape measures. Besides, ears of wheat were automatically recognized and their size was estimated using laser scanner data. Thus, this study shows that a laser scanner could be used as a precision-farming tool in agriculture.

Osman et al. (2009) evaluate the effect of some helium-neon laser treatments on fennel and coriander plants. The dry and wet fruits of fennel and coriander plants were exposed to helium-neon to laser for 5, 10, and 20 min with a power density of 95 mW/cm^2. In most cases, the tallest plants, the 2 highest number of branches per plant, number of umbels and essential oil percentages were obtained from the treatment of 20 min. Helium-Neon (He-Ne) laser exposure for wet fruits. The highest fruit yield of fennel resulted from 5 min of exposure for dry coriander fruits. While in coriander, the highest yield was obtained from 20 min of exposure treatment for wet fruits. The highest values of nitrogen and phosphorus were found in the same treatment. The highest content (71.79%) of the main component of the fennel oil (t. anethole) was obtained from the exposure of fennel fruits to helium-neon at 5 min. on the wet case. In coriander, the highest content of the main component linalool (67.44%) was obtained from exposure to helium-neon of 10 min. on the wet case.

Ćwintal et al. (2010) Alfalfa samples were subjected to stimulation 1, 3, and 5 times with a divergent beam of He-Ne laser. Alfalfa was harvested in the 3-cut system in years of full land use. Plant samples were used to determine the content of dry matter, total protein, a specific protein, crude fiber, phosphorus, potassium, calcium, magnesium, copper, manganese, zinc, boron and molybdenum. Pre-sowing stimulation of seeds with laser light, at doses R6x5 and R6x3, caused a significant increase in the content of specific proteins, phosphorus and molybdenum, while decreasing the content of crude fiber in the dry matter of the plants.

Podleśny et al. (2012) determined the changes of some biochemical and physiological processes, which occurred in seeds and seedlings of white lupine and faba bean after pre-sowing treatment with laser beams. It was found this treatment of seeds considerably increased the activity of amylolytic enzymes in seeds of both plants. The irradiated seeds of white lupine and faba bean had higher fresh weight at the time of imbibition than the seeds which were not treated with laser beams. It resulted in earlier and more uniform germination. The concentration of free radicals increased considerably in the seeds pre-treated with laser beams and the largest increase in seeds of both plant species was noticed after five exposures to laser beams.

2.3. Factors affect on seed storage

Azadi and Younesi (2013) reported that the physical and chemical seed characteristics were decrease under long storage conditions due to aging. Changes that occur in seed during ageing are significant in terms of seed quality, the feature that, among other things, also implies seed longevity. The progress of technology and industrialization of agricultural production has increased opportunities for long-term storage of seeds. Aging conditions reduce seed vigor. The purpose of proper storage is to inhibit biological processes to the highest possible extent and to eliminate unfavorable environmental factors, which limit the duration of safe storage. The seed deterioration can be defined as the loss of quality, viability and vigour either due to againg or effect of adverse environmental factors.

Parimala et al. (2013) explained that the storage of seeds is initiated at the time of attainment of physiological maturity and maintained until the next sowing season. Hence, the different stages involved in seed storage are as follows:

(a) Period from physiological maturity to harvest, (b) Period from harvest to packaging, (c) Period from packaging to storing, (d) Period from storing to the marketing of seeds and (e) On-farm storage (Purchased seeds used for planting in the field).

Venkatachalam and Ilamurugu (2011) reported that seeds must be stored, of course, because there is usually a period of time between harvest and planting. During this period, the seed must be kept somewhere. While the time interval between harvest and planting is the basic reason for storing seed, there are other considerations, especially in the case of extended storage of seed. The purpose of seed storage is to maintain the seed in good physical and physiological conditions from the time they are harvested until the time they are planted. It is important to get adequate plant stands in addition to healthy and vigorous plants.

Principles of storage

(a) seed storage conditions should be dry and cool, (b) effective storage pest control, (c) proper sanitation in seed stores, (d) before placing the seeds in storage, should be dried to safe moisture limits and (e) Storing of high-quality seed only i.e., cleaned well treated and high germination and vigor.

2.3.1. Seeds quality:

ASAE (2000) reported that Bulk density is an important physical property that is required to estimate the volume of storage and pressure that act on storage bin walls.

Nimkar and Chattopadhyay (2001) reported that the size, thousand grain mass, angle of response, geometric mean diameter, terminal velocity and bulk porosity of green gram were increased with increasing MC from 8.39 to 33.40% (d.b.), while, the sphericity, bulk density and the true density were decreased with the specified moisture level, as shown in Fig (2-1)

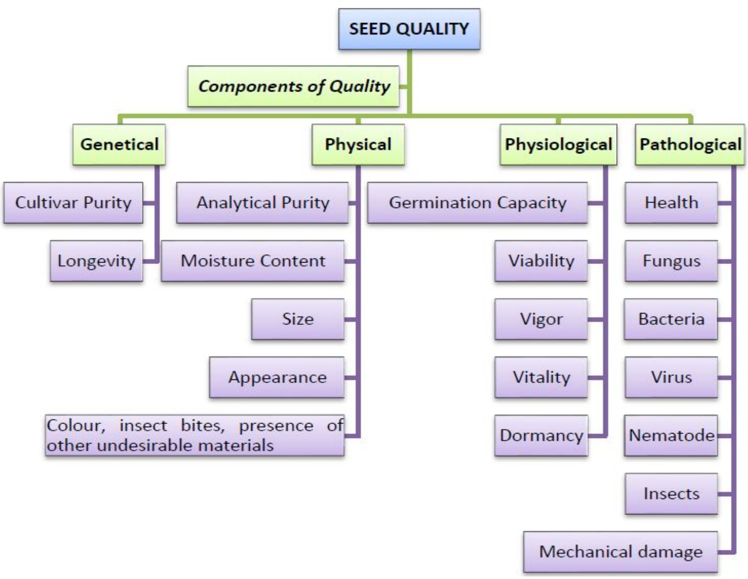


Fig. 2-1: A structural concept of seed quality

Brownfield (2006) stated that various species are predisposed to maintain seed quality better and longer than others, while in storage, and the storage conditions directly impact the longevity of seed quality. It is possible that within each of these species, the seed of certain subspecies or varieties may also maintain quality in storage longer than others. Initial seed quality needs to be established as a base for the evaluation of seed deterioration. This can be done as a combination of germination testing and vigor tests (such as cold, emergence rate, and/or electro conductivity tests).

Parimala et al. (2013) reported that seed storage is greatly influenced by the kind and variety of seeds. Some seeds have a short storage life (eg. Groundnut, Soybean), some have medium storage life (eg. Wheat, Cotton) and some, such as rice and beans can be stored for a longer period. The healthy and undamaged seeds can be stored for a longer period, compared to damaged and deteriorated seeds.

Walsh et al. (2014) mention that seed quality is defined along two broad dimensions: seed quality and varietal quality. It is important to think of the two as distinct: It is seed quality which is particularly affected by storage technology. Seed quality consists of health, physiological and physical attributes.

Hasanuzzaman (2015) stated that the quality of the seeds is considered as an important factor for increasing yield. The use of quality seeds greatly helps in higher production per unit area to attain food security of the country. Quality seeds have the ability for efficient utilization of the inputs such as fertilizers and irrigation.

Shoughy and Amer (2006) clearly showed that faba bean physical and mechanical properties are very important in the design equipment for handling, drying, aeration, storing structures and processing.

Venkatachalam and Ilamurugu (2011) explained that seed storability is considerably influenced by the kind or variety of seeds. Some seeds are short-lived. E.g.: Onion, Soybean and Groundnut. As a general rule, starchy seeds can be stored considerably for a longer period compared to proteinaceous or oily seeds because of their hygroscopic nature. Seed lots having plumpy, vigorous undamaged seeds stores longer than that of deteriorated. Even seed lots having good germination at the beginning of storage period may deteriorate at a faster rate depending upon the severity of weathering damage, mechanical injury or otherwise in the field. The low-quality seeds should invariably be rejected. Even at best storage conditions, the initial quality of the seed cannot be improved (except for the dormant seed) but can only be maintained.

2.3.2. Moisture content of the seeds:

Brownfield (2006) stated that initial seed moisture content (MC) for storage should range between 5and 14% to maximize shelf life. When combined with the correct RH, the correct seed MC can help produce safe seed storage conditions for up to one year.

Parimala et al. (2013) reported that seeds with more than 14% of MC quickly deteriorate, whereas very low MC is also detrimental to seed quality. When the moisture level below 5% causes physiochemical changes in the seeds, whereas above 14% it is prone to insect and mold attack. The safe moisture level of cowpea is 9%.

FAO (2014) reported that MC is described as the quantity of water bound in the grain kernels expressed as a percentage by weight of the grain or seed sample. The MC of dry grain ranges from 6 to 15%, depending on the type of grain. MC is a determining factor in the proliferation of mold and storage pests.

Walsh et al. (2014) showed that since the life of a seed largely revolves around its MC, the moisture content of the seed as it is placed in storage and the RH of the store are the most important factors influencing seed viability during storage. Before placing seeds in storage, they should be dried to a safe moisture limit, although this varies considerably by crop. Very low MC below 4% may also damage seeds, due to extreme desiccation. At lower levels of humidity, seeds can usually be stored for longer periods.

Venkatachalam and Ilamurugu (2011) explained that the most important factor influencing seed viability during storage is the MC and the rate of deterioration increases, as the seed MC increases. The drier the seed the higher will be the storage life. Higher MC enhances the biological activity in the seeds and causes excessive heating, besides promoting mould and insect activities.

2.3.3. Relative humidity (RH) and Temperature.

FAO (1994) reported that the MC of grain plays a crucial role in post-harvest processing and is associated with most of the induced characteristics. Water vapour will diffuse throughout a bulk of grain and the MC will tend to equalize. 'Hot spots' may occur at a site of increased respiration (caused by sprouting, infestation or microbial activity), and condensation may occur on cold grains or containers.

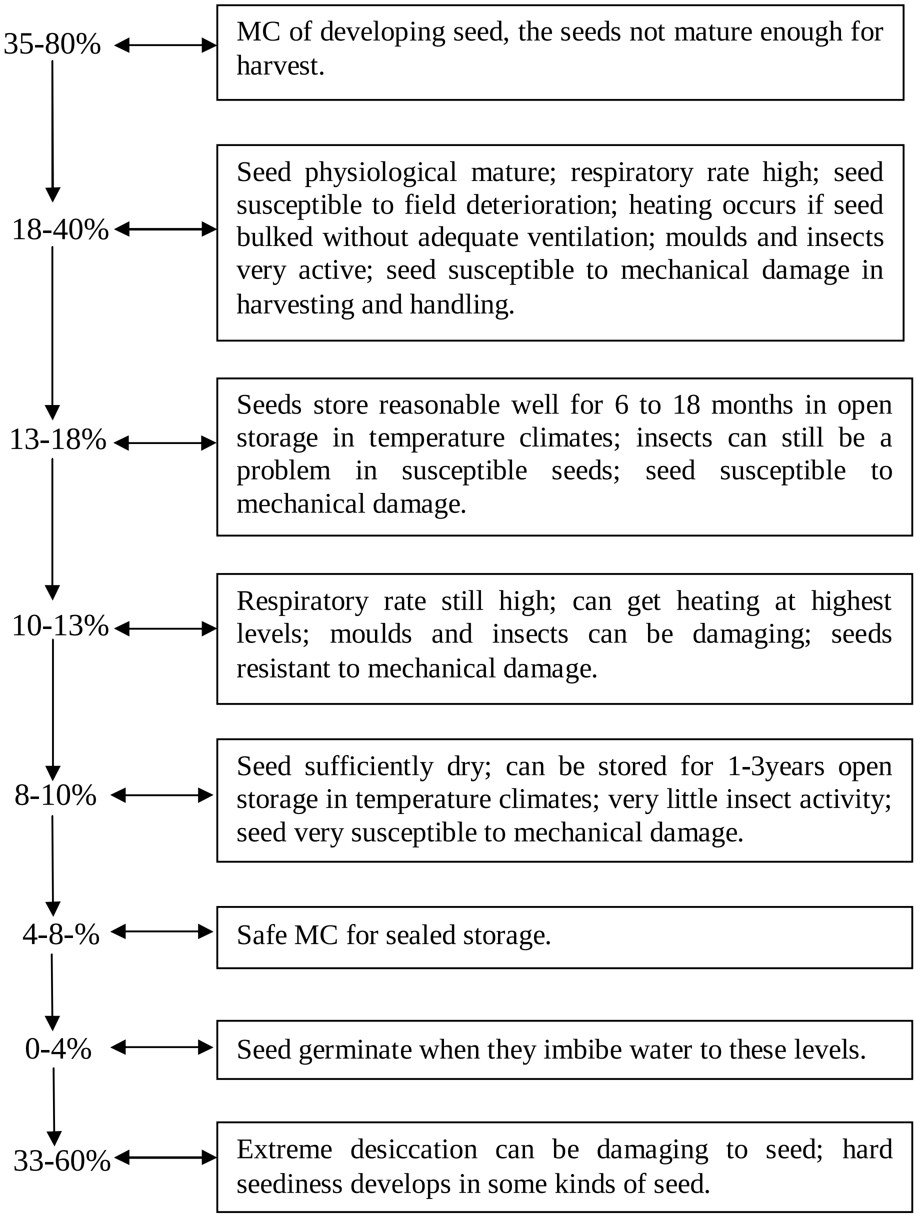


Fig (2-2): Role and importance of MC in the life of seeds.

Brownfield (2006) stated that storage temperature must be derived from this formula when assessing storage unit effectiveness:

$$°F + RH \leq 100$$

Lower relative humidity means higher allowable storage temperatures, as long as their sum does not exceed a combined value of 100. For example, storage areas with an RH value of 60% need to be cooled to 40˚ F to enhance maximum storage potential. Higher temperatures can be especially damaging if the seed is stored at higher moisture contents. Seed stored with lower moisture contents may tolerate higher temperatures better.

Nasar-abbas et al. (2008) maintain that legume seeds are mostly preserved in dry storage at ambient temperature to maintain a year-round supply of this important protein food source.

Ken (2007) stated that the numbers of common grain pests can increase by 20-25 times a month at typical grain harvest temperatures of 30^0C and grain MC of 14% for wheat {equivalent to 73% RH}. Reducing grain temperature slows insect development. For example, flour beetles can complete their development in three weeks at 35^oC and 70% RH, but take ten weeks at 22.5^oC and 70% RH. Although adult grain insects live a long time at cool temperatures, their early stages stop developing at temperatures below 20^0C for most species or below 15^0C for rice weevil.

McCormack (2010) reported that the general effect of temperature on longevity is that longevity increases as temperature decreases. The relationship between temperature and seed longevity is that for each (5.6^{o}C) decrease in temperature, longevity doubles. This rule applies to seeds stored between temperatures of (0^{o}C) and (50^{o}C). This rule assumes that the MC is constant.

FAO (2011) showed that high MC leads to storage problems because it encourages fungal and insect problems, respiration and germination. However, the MC in the growing crop is naturally high and only starts to decrease as the crop reaches maturity and the grains are drying. In their natural state, the seeds would have a period of dormancy and then germinate either when re-wetted by rain or because of naturally adequate moisture content.

Parimala et al. (2013) outlined that seeds are hygroscopic. Hence, they attain specific MC when subjected to a given level of atmospheric humidity at a particular temperature. Seeds should be stored in dry and cool conditions to ensure the quality of the seeds during storage. The seeds were harvested from an area of high RH and temperature at the time of seed maturation or harvest can be stored for a lesser period than the seeds from low RH and moderate temperature area, as shown in Table (2–2).

Table (2-2): The general RH and temperature for multiplication of various biological organisms in seed storage is as follows

Organism	Temperature, °C		RH (%)
	Range for multiplication	Optimum range	
Insect	21-24	27-37	30-95
Mites	8-31	19-3	60-100
Fungi	8-80	20-40	60-100
Microbes	8-80	26-28	91-100

FAO (2014) reported that storage insects and mold thrive within an optimal temperature range: between 25 and 34 ºC for most storage insects, and between 15 and 30 ºC for the development of mold. Beyond this range (colder or hotter), the development of these threats to the stored products is limited, and therefore the losses as a result are negligible. Also, it added that RH is the percentage of water vapour in the air between the grains, and represents the equilibrium between the humidity of the air and the MC of the grain. If the RH exceeds 65%, mold and storage insects can develop and stored grain and seed are susceptible to deterioration.

Rajasri and Kavitha (2015) outlined that temperature ranging from 20 to 40^{o}C accelerates the development of insects, but above 42^{o}C and below 14^{o}C retards reproduction and development, whereas prolonged temperature above 45^{o}C below 10^{o}C may kill the insects, Heating of grains to 50^{o}C will be lethal to insects but it is not advisable because the grains are affected and lose the viability. The MC of grain: Moisture is the critical factor in the safe storage of food grains. Grains stored at around 10% MC escapes from the attack of insects (except khapra beetle).

Venkatachalam and Ilamurugu (2011) explained that Seeds are hygroscopic. They attain rather specific and characteristic MC when subjected to a given level of atmospheric humidity at a particular temperature (equilibrium MC). The equilibrium MC for a particular kind of seed at a given relative humidity tends to increase as temperature decreases and the deterioration starts. The equilibrium MC varies among seed kinds. Generally, the equilibrium MC of “oily” seed is lower than that of “starchy” seed at the same RH and temperature.

2.3.4. Activity of insects and other microorganisms.

Parimala et al. (2013) explained that bacteria, fungi, mites, insects, rodents and birds may affect the seeds in storage. Bacteria do not show any significant effect on stored seeds since it needs water for its proliferation. Storage fungi like Penicillium infect seeds and produce mycotoxins that will deteriorate seed quality. Insects and mites cause severe damage, especially in warm and humid conditions. Birds and rodents cause huge loss of seeds during the storage period.

Hasanuzzaman (2015) mentioned that seed suffer in qualitative and quantitative loss during storage due to several biological factors, insect sharing major claim. The insects found most commonly in stored are rice weevil, granary weevil, lesser grain borer, angoumois grain moth, cadelle, saw toothed grain beetle, flat grain beetle, flour beetle, bruchid beetle, dermestids, bruchids, several bean and cowpea weevils, Indian meal moth and almond moth.

Sallam (2008) showed that insect pests inflict their damage on stored products mainly by direct feeding. Some species feed on the endosperm causing loss of weight and quality, while other species feed on the germ, resulting in poor seed germination and less viability. Thus, due to the damage done by insects, grains lose value for marketing, consumption or planting. Most storage pests can increase in numbers drastically within a relatively short time.

Venkatachalam and Ilamurugu (2011) explained that bacteria, fungi, mites, insects, rodents and birds may harm seeds in storage. The general limits of temperature and relative humidity for the multiplication of the various biological agencies infesting stored seeds are, it is also interesting to note that the favourable limits of temperature and RH for germination are 16-42^{o}C and 95–100 percent, respectively.

2.4. Losses in storage

Boxall (2002) explained that the maximum amount of losses occurs during the storage of crops due to a lack of adequate infrastructure. Storage losses can be classified into two categories: direct losses, due to physical loss of commodities; and indirect losses, due to loss in quality and nutrition. It is important to consider both damage and losses by the insects during storage instead of just weight loss. “Damage” can refer to physical evidence of deterioration, for example, holes in the grains. It mainly affects the quality of grains. “Loss”, on the other hand, refers to the disappearance of food, and is directly measurable in quantitative, qualitative, nutritional, or economic terms.

Aulakh and Regmi (2013) said that food losses can be quantitative as measured by decreased weight or volume, or can be qualitative, such as reduced nutrient value and unwanted changes to taste, color, texture, or cosmetic features of food. Quantitative food loss can be defined as a reduction in the weight of edible grain or food available for human consumption. The quantitative loss caused by a reduction in weight due to factors such as spillage, consumption by pest and due to physical changes in temperature, MC and chemical changes. This definition is unsatisfactory since food grains undergo a reduction in weight due to drying, a necessary postharvest process for all grains.

Rajasri and Kavitha (2015) and FAO (2011) outlined the losses caused by insects:

<u>Weight loss:</u> Estimates of the weight loss as a result of insect feeding vary widely with the commodity, locality and the storage practices involved. For grain legumes in the tropics, stored under traditional conditions, a loss in the range of 10-30 per cent might be expected over a full storage season.

<u>Loss in quality/market value:</u> Infested produce contaminated with insect debris has increased dust content. Grains are holed and often

discolored. Food prepared from infested produce may have an unpleasant odour or taste.

Promotion of mould development: Insects, moulds and the grains themselves produce water in respiration, i.e. a breakdown of carbohydrate substrate. In humid conditions, without adequate ventilation, mould development and “caking” can spread rapidly, causing severe losses.

Reduced germination in seed material: Damage to the embryo of the seed will usually prevent germination.

Reduced nutritional value: Removal of the embryo by storage pests will tend to reduce the protein content of the grain.

Srivastava and Sabtharishi (2016) summarized that pulse beetle *Callosobruchus maculatus* (*Coleoptera: Bruchidae*) is a very important pest of grain legumes both in storage and field. It is distributed throughout India. It attacks peas, chickpea, pigeon pea, black gram, horse gram, cowpea, etc. Larva which grows inside eats endosperm, and then the seed was damaged. Infestation starts from maturing pods. Females lay about 80–100 eggs per individual; the eggs are attached to the substratum using of transparent glue like substance. Freshly laid eggs are creamy but become white later on.

Egg period is for 3-7 d. Adults come out of the seed after pushing out a circular lid prepared by the prepupal stage of larvae.

2.5. Storage methods

FAO (1987) said that methods are quite often associated with the drying of the crop, and are primarily intended to serve this purpose. They assume the function of storage only if the grain is kept in place beyond the drying period (i) Aerial Storage: Maize cobs, sorghum or millet panicles are sometimes tied in bundles, which are then suspended from tree branches. This method is not suitable for very small or very large quantities and does not protect against the weather, insects, rodents, or thieves, and (ii) Storage on the ground, or on drying floors: this method can only be provisional since the grain is exposed to all pests.

FAO (1994) explained that this method of storage is used in dry regions where the water table does not endanger the contents. Conceived for long term storage, pits vary in capacity (from a few hundred kilo-grammas to 200 tonnes). Their traditional form varies from region to region: they are usually cylindrical, spherical or amphoric in shape, but other types are known. The entrance to the pit may be closed either by heaping earth or sand onto a timber cover, or by a stone sealed with mud. (iii) Open Timber Platforms: Grain is stored on platforms in heaps, in woven baskets or bags. In humid countries fires may be lit under elevated platforms, to dry the produce and deter insects or other pests.

Brownfield (2006) stated that the type of seed packaging/container used can also effect on shelf life, particularly if the RH is high. Some types of packaging can absorb moisture from the air, or allow it to penetrate to the seed. Seed will then imbibe the moisture, eventually equilibrated with the surrounding air. This can result in a shelf life reduction if the seed becomes too moist. RH is not so important if seed is stored in hermetically-sealed containers or another non-absorbent packaging that does not allow the moisture to penetrate into the seed.

Karthikeyan (2009) mentioned that about 200 gm of salt was mixed for a kg of red gram grains manually. These treated grains were then stored in jute gunny bags and the bags were stitched. Due to this practice, insects were kept away from the stored grains. As salt had an abrasive action on insect skin prevents its movement inside the storage containers. Farmers believed that this practice stored red gram grains, for the short-term duration of 6–8 months. Farmers perceived this practice was moderately effective and affordable in cost.

Also, **Karthikeyan (2009)** explained that ash was mixed with the sorghum (Sorghum bicolor) seeds at the ratio of 1:4. After the ash treatment, sorghum seeds were tied airtight in the jute gunny bags. During storage, grains were subjected to losses by various insects, e.g., rice weevil (Sitophilus oryzae), rodents (Tatera indica) and mite (Oligonychus indicus). Farmers strongly believed that ash applications controlled these losses considerably up to an extent of 80%. Farmers using this technology stored the sorghum grains for 6 months without any storage pest problems.

Parimala et al.(2013) stated that wood ash is a safe and effective pest control material. Mix equal quantities of seed and wood ash to prevent the attack of beetles and other storage pests.

2.5.1. Storage using Ultraviolet irradiations.

Forney et al. (2009) and Ribeiro et al. (2012) and Pinheiro (2015) defined the wavelength for UV processing ranges from 100 to 400 nm. This range may be further subdivided into UV-A (315–400 nm), normally responsible for changes in human skin called tanning; UV-B (280–315 nm), which can cause skin burning and eventually lead to skin cancer; UV-C (200–280 nm), called the germicidal range since it effectively inactivates bacteria and viruses; and the vacuum UV range (100–200 nm), which can be absorbed by almost all substances and thus can be transmitted only in a vacuum. Short UV-C is almost completely absorbed in the air within a few hundred meters. When UV-C photons collide with oxygen atoms, the energy exchange causes the formation of ozone. UV-C is almost never observed in nature since it is absorbed so quickly, as shown in fig (2-3).

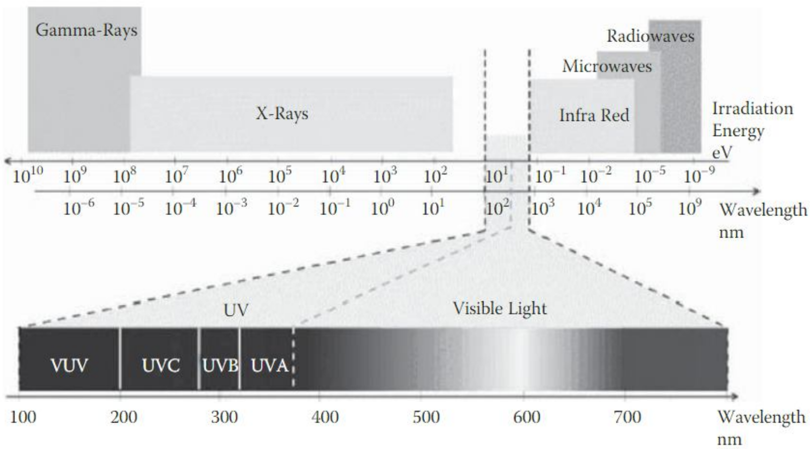


Fig. 2-3: Electromagnetic spectrum

Ribeiro et al. (2012) reviewed that the use of UV light is well established for water treatment, air disinfection, and surface decontamination, its use is still limited in food treatment and in postharvest technology in particular. UV treatment has the potential for commercial use as a surface treatment of fresh-cut fruits. The ability of UV light to sanitize and retard microbial growth on the surface of fresh-cut fruits without causing undesirable quality changes has recently been recognized.

Pinheiro (2015) mentioned that UVC radiation is widely used as an alternative strategy to control microorganism in food products. Microorganisms that are exposed to UV light are affected at the DNA level. Thus, the injured reproduction systems of cells lead to their death.

Faruki et al. (2007) reported that the eggs of the stored grain pests, *Tribolium castaneum* (Herbst), *T. confusum* (Duval) (Coleoptera: Tenebrionidae) and *Cadra cautella* (Walker) (Lepidoptera; Pyralidae) belonging to three age groups, 1, 2, and 3 days old, were exposed to (UV) radiation with 254nm wavelength (UVC) for different durations to determine irradiation effects on egg-hatching and adult emergence. An increase in time of exposure to UV-rays caused a gradual decrease in the percentage of hatching of eggs in all age groups of eggs. All exposure periods significantly reduced the eclosion of adults in all experimental insects.

Forney et al. (2009) mentioned that the UV light in food processing is typically used to prolong the shelf life of food products or to reduce health hazards associated with certain products due to the presence of pathogenic microorganisms. The treatments may be applied for different purposes. These may include prolongation of the shelf life and prevention of food-borne diseases fresh juices, drinks, and other beverages; fresh produce, meat, poultry, and seafood; and in retardation of ripening and ageing of fruit and vegetables.

Collins and Kitchingman (2010) stated that the principle, UVC radiation may provide an effective means of combating pest infestations associated with the structure of a building and may serve as a potential new hygiene measure. UVC is short-wavelength (100–280 nm) radiation and is primarily used for the disinfection of air, surfaces and liquids from microbial contaminants. The UV destroys the DNA of bacteria and other microbial contaminants, thereby preventing further replication and growth. The use of UVC radiation as a method of pest control has not been extensively investigated due to the perceived risks to human health and the lack of penetration. Through substrates. The limited penetration therefore precludes its use as a treatment for bulk commodities. It may, however, offer potential as a surface hygiene treatment in empty stores.

Hidaka and Kubota (2006) said that UV sterilization was applying directly on microorganisms that adhere to the surface of the wheat, and then checked the quality. Sterilization tests indicated that the required sterilization time to obtain a 90% sterilization rate was 6.3 h for bacteria and 5.6 h for mold using 254 nm wavelength and 97 W/m2 UV irradiance. The germination and amylograph tests suggested that quality was minimally affected by UV irradiation in this range.

Erdo˘gdu and Ekiz (2011) tested the effect of UVC and FIR treatment on microbial decontamination and quality of cumin seeds. For this purpose, FIR treatment at different exposure times and temperatures was applied, followed by constant UVC treatment with an intensity of 10.5 mW/cm^2 for 2 h. Total mesophilic aerobic bacteria of cumin seeds were decreased to a target level of 10^4 CFU/g after 1.57, 2.8, and 4.8 min FIR treatment at 300, 250, and 200 ˚C, respectively, following a 2 h UVC treatment. Under the given conditions, complete elimination of total yeast and moulds were obtained, while there were no significant changes in volatile oil content and color of the cumin seeds. Consequently, combined UVC and FIR treatment was determined to be a promising method for the decontamination of cumin seeds.

2.5.2. Storage using Laser irradiation:

Podleœny (2002) evaluated some biochemical and physiological changes in the seeds and give a detailed description of the dynamics of the accumulation of dry matter of the faba bean after application of the presowing biostimulation of seeds with laser light. It was found that there was a significant effect of seed biostimulation on the scale and rate of dry matter accumulation of particular faba bean organs; the three-fold dose increased the dynamics in the above- ground part, whereas the five-fold dose, to that in the roots. The weight of vegetative organs intensively reached the phase of faba bean flowering; the highest increase in the total aboveground part of the weight was noted during flowering and pod setting and was followed by a very fast increase in the weight of the generative organs. Irradiation of the seeds significantly influenced plant germination and modified the course of particular developmental stages of the faba bean, resulting in accelerated germination and maturity of the plant.

Abu-Elsaoud et al. (2008) found that the influence of infrared laser on four wheat cultivars from Kazakhstan and Egypt were carried out to enhance their germination percentage. Seeds were in vitro irradiated with IR laser for 0, 1, 3, 10, 30, 60, 180, 600, 1200, and 1800 sec. Seeds pre-sowing irradiation with monochromatic infrared (IR) laser has increased the germination percentage of the four wheat cultivars. Maximum germination percentages noticed were mainly after IR-seed pre-sowing irradiation with 1, 60, and 1200 sec.

Chen et al. (2010) determined the effect of CO_2 laser pretreatment of wheat seeds on the physiological tolerance of seedlings to chilling stress, wheat seeds were exposed to CO_2 laser radiation for 300 s. After being cultivated for 48 h at 25C, the results suggest that a suitable dose of CO_2 laser stimulation can enhance the physiological tolerance of wheat seedlings to chilling stress.

Hernandez et al. (2010) reviewed that mechanisms of laser biostimulation have not been understood entirely, the application of this phenomenon in the agricultural sector could have a wide range of practical applications for farmers and seed industry. The type of laser used will depend on the technical characteristics and cost. The effects of laser irradiation for biostimulation can be positive, negative, or none. It is necessary to investigate the parameters of laser light irradiation to produce favourable effects of biostimulation conditions according to the seed itself and environmental conditions.

laudia at al. (2011) investigated the effects of low intensity laser irradiation on the mycoflora content in maize seeds. Five irradiation times (30, 60, 180, 300 and 600 s) and two intensity levels (I_1 = 16.3 e and I_2 = 4.6 mW/cm^2) were applied by using a diode laser (l = 655 nm `and power of 27.4 mW). Consequently, the laser irradiation significantly diminished the number of seeds infected with Fusarium spp. fungi. The combination of I_1 and I_2, at 5 min of irradiation time, diminished ($p \leq 0.05$) the number of infected seeds with Fusarium spp. up to 61.11% compared with the control seed (no irradiation). So the low-intensity laser irradiation could be an alternative method to control seed transmitted diseases in maize seed.

Yasemin et al. (2013) investigated the effect of Hard wheat (Triticum durum) seeds exposed to visible light with ג= 632 nm, 650 nm and 532nm produced from He-Ne, Diode, and SHG Nd-YAG lasers, respectively, on germination early growth and resistance to fungal infections had been studied under laboratory conditions. He-Ne and diode laser enhanced the germination percentage of wheat cultivars after two days a maximum of 95and 93% after irradiation, respectively, for 5 min with respect to control, with the beginning to infection with fungus in both the irradiated and non-irradiated seeds, SHG Nd-YAG laser significantly enhanced the germination percentage of wheat after 3 days to reach a maximum of 93% after irradiation. Seeds irradiated with SHG Nd-YAG laser,no fungus infection was recorded, while seeds irradiated by the two other types highly show infection, especially after 3 days and the petri plates which added to them antifungal agents showed a significant increase in infection with and without irradiation. From these results, they concluded that SHG Nd-YAG laser irradiation could be an alternative method to control the seed infection by fungi of hard wheat seeds.

Hori et al. (2014) showed that the lethal effects of visible light on insects by using light-emitting diodes (LEDs). The toxic effects of ultraviolet (UV) light, particularly shortwave (i.e., UVB and UVC) light, on organisms are well known. They found that irradiation with short-wavelength visible (blue) light killed eggs, larvae, pupae, and adults of Drosophila melanogaster. Blue light was also lethal to mosquitoes and flour beetles, but the effective wavelength at which mortality occurred differed among insect species. They findings suggest that highly toxic wavelengths of visible light are species-specific in insects and that shorter wavelengths are not always more toxic. For some animals, such as insects, blue light is more harmful than UV light.

Sharma et al. (2015) reviewed that laser light has many applications in agriculture, but there is still much work to provide scientific evidence of its potential use as an alternative for the control of diseases originating in the seed, especially for internal fungi. Even laser treatment has been reported to be effective, although laser beams are narrow and the entire surface of the seed should be evenly exposed for good effect, it is of limited practical interest.

Mistry and Keshatti (2017) determined the influence of He-Ne Laser on germination and electrical conductivity of soybean seeds revealed suppressive effect compared to a non-irradiated seed. The soybean seeds were exposed to a He-Ne laser irradiation with a wavelength 632.8 nm. Soybean seeds were divided into two groups. The first group for germination test and the second group for electrical conductivity test were irradiated for 0, 5, 10, 15, and 20 min. The electrolyte leakage was measured using the conductivity test. The seeds irradiated with a He-Ne laser gave significant results in increasing germination percentages and vigour index, but electrical conductivity decreased. The highest germination percentage (92%) was observed for 15 min irradiation.

2.6. Effect of Insect on seeds:

Boxall (2002) said that during the first few months of storage, insect infestation and percentage loss recorded in samples may be low, but the insect infestation typically increases with time and so at the end of the season there will be a high percentage loss in the samples. However, this high loss applies only to the small quantity of grain remaining in the store. Although high figures serve to demonstrate the dramatic damaging nature of the pest, they do not accurately reflect the real loss experienced by the farmer.

Shadia (2011) stated that insects: (Beetles, weevils and borers): the stored grain of almost any kind is subject to attack by insects. Pests which attack whole grains usually develop and feed inside the kernels of grain. These pests are not usually capable of existence outside the grain kernel as immature insects. Examples of wholegrain pests are rice weevil, the granary weevil, lesser grain borer and the angoumois grain moth. Also, she added that the other insects which attack grain are usually unable to penetrate the whole grain. These insect pests, however, can attack grain after it has been either mechanically broken or attacked by whole grain insects. Examples of these secondary pests are the confused and red flour beetles, Indian meal moth, Mediterranean flour moth and the sawtoothed grain beetle.

Shimoda and Honda (2013) stated that light affects insect behavior and development in various ways that can be divided into several categories. One of the most typical responses to light is phototaxis.

Srivastava and Sabtharishi (2016) outlined that stored product pests gain access to grain storage from the standing crop in the field to various stages of grain processing and storage. Although, about one thousand species of insects have been associated with stored products in different parts of the world, a few pests are considered as pests causing severe damage to the stored grains. The stored grain insect pests can be categorized based on their feeding behavior as internal and external feeder or as major and minor pests based on the severity of the damage, they cause. Understanding the symptoms of damage, life cycle and biology of major stored product insect pests would help in monitoring and assessment of their damage to devise suitable strategies for controlling these pests. Grain handlers are essentially to be imparted with the knowledge of identification of major stored product insect pests, their life stages and associated damage symptoms in the grains to ensure safe storage of grains.

Shimoda and Honda (2013) mentioned that insects exhibit the following phototactic behaviors

(A) Attraction (positive phototaxis, moving toward a light source)

(B) Repulsion (negative phototaxis, moving away from light)

(C) Light adaptation is when nocturnal insect species become light-adapted within several minutes of light exposure.

(D) Circadian rhythms are daily behavioral rhythms including flight, locomotion, feeding, courtship, mating.

(E) Photoperiodicity is the physiological response of insects to the light schedule (i.e., day length).

F) Light toxicity occurs when the retinas of compound eyes of an insect exposed to UV and blue light radiation are damaged and structurally degenerated.

(G) Insects will not actively fly toward something they cannot see.

(H) Finally, some free-flying insects show a dorsal light reaction, where they stabilize their horizontal orientation (attitude) by perceiving light that shines on their dorsal side as sunlight does during flight.

These responses to light are substantially influenced by a variety of factors, including light intensity and wavelength, combinations of wavelengths, time of exposure, the direction of a light source, and the contrast of light source intensity and color to that of ambient light. In addition, the impact of light on insect behavior varies both qualitatively and quantitatively depending on the light source (LED) and material (light-reflecting plate)

FAO (2014) and Brann (2009) mention that storage insects are categorized as either primary or secondary pests. Primary insect pests are those which are capable of invading an undamaged grain and establishing an infestation, although they can also feed on damaged grains. Most primary pests can also start their attack in the field before harvest. Secondary insect pests attack or establish themselves on grains damaged or attacked by primary storage pests.

(FAO 2011) stated that insect control techniques

• Sanitation: Do not mix the new grain with old. Old, infested material should be removed or thoroughly fumigated. Clean the storage structures and machinery, and disinfect bags and baskets by sunning or chemical treatment. Large structures will require chemical treatment, while smoke may be adequate for small stores.

• Natural resistance: Crop varieties differ in their susceptibility to storage pests. Traditional varieties are usually more resistant to storage pests than new varieties. For instance, maize with good husk cover can reduce the field infestation.

• Hermetic storage: In airtight conditions, reduced oxygen and increased carbon dioxide will arrest insect and mold development.

• Chemical control: The traditional method for preserving the crop in storage is to treat the grain with smoke and special plants or, when stored in closed containers, to mix grain with ash or sand. While this method is widely used for small volumes, such as seeds, for larger quantities the method becomes cumbersome.

Upadhyay and Ahmad (2011) reported that the number of stored grain insect pests that infest food grains in farmer stores and public ware houses and massive surge due to uncontrolled environmental conditions and poor ware housing technology used. However, for suppression of multiplying insect populations highly specific and more appropriate modern methods are to be used. Few important methods such as microwave and ionizing irradiation, pheromone-baited traps, IGRs and use of entomopathogens are proved highly effective against stored grain insects. Over these methods, repellents and oviposition inhibitors isolated from various plant species are considered much safer than synthetic pesticides. These natural pesticides have no side effect and are biodegradable in natural the environment. However, non-residual non-persistent and less toxic bio-organic pesticides should be used that may not affect the quality of food grains. Besides this, low pressure and low-temperature treatments are proved to be much safer pest management tools representing a potential alternative of fumigants to control coleopteran and lepidopteran insects. However, for effective control of stored grain insects various sparasitoids, predators, pathogens and other living organisms are employed in natural conditions to suppress the pest population. For better protection of stored grain control computer-based decision support systems should be used to predict damage and operation requirements for timely control.

Also, both biological and non-biological factors and their effects must be evaluated to check the possible infestation during storage.

Therefore, selected control strategies must be integrated for effective management of stored grain insects.

2.7. Image processing:

Leon et al. (2006) reviewed that the color of the food surface is the first quality parameter evaluated by consumers and is critical in the acceptance of the product, even before it enters the mouth. The color of this surface is the first sensation that the consumer perceives and uses as a tool to accept or reject food. The observation of color thus allows the detection of certain anomalies or defects that food items may present.

Dana et al. (2008) applied computer image analysis to group together flax cultivars (*Linum usitatissimum L.*) according to their similarity in commercially important dry seed traits. Both seed shape and seed-color traits were tested on 53 cultivars from world germplasm collections.Four shape traits (Area, Perimeter, MeanChord, and MinFeret) and three color traits (L*, a*, b* calculated from original RGB color channels as CIE color space coordinates) were computers extracted from digital images of 62349 seeds with 1200 seeds per cultivar on average. Based on these results, they recommend that current qualitative sensorial seed descriptors routinely used for cultivar characterization may be supplemented by more informative continuous quantitative descriptors obtainable at low cost from dry flax seeds.

Durmas et al. (2010) concluded that the digital image system was used for determining geometric features of bean and lentil seeds. The approximation of a 3-D model was used to calculate the surface area and volume. A triaxial ellipsoid approximation method was suitable for most of the bean varieties except white speckled red bean from Turkey. The percentage difference between volumes was estimated using the pycnometric method and triaxial ellipsoid approximation method ranged from 0.49% to 6.14%. For red speckled red bean from Turkey, the two sphere segments approximation models give the best fit to volumes measured pycnometrically. Also, the two sphere segment approximations were more suitable in the volume computation of both red and green lentils than oblate sphere approximation. The percentage difference between volumes estimated using the pycnometric method and two sphere segments approximation method ranged from 4.22 to 5.14%. Digital image processing approach could be a simple, rapid, and noninvasive alternative to traditional measurement methods.

Omid et al. (2010) reported that machine vision has been found increasingly useful in the agricultural and food industry, especially for applications in quality inspection, meeting quality standards, and increasing market value. In fact, machine vision is the most effective tool for measuring external features such as color intensity, color homogeneity, bruises, size, shape, and stem identification.

Costa et al. (2011) stated that the appearance of agricultural products deeply conditions their marketing. The appearance is normally evaluated by considering the size, shape, form, color, freshness condition and finally the absence of visual defects. Among these features, the shape plays a crucial role. Description of agricultural product shape has been necessary to research fields for a range of different purposes, including the investigation of shape trait heritability for cultivar descriptions, plant variety or cultivar patents and evaluation of consumer decision performance.

Velioğlu and Saglam (2012) said that image processing techniques have been widely used in the determination of shape, color, texture and size of agricultural products. A manual measurement technique has been replaced by image processing according to the advantages such as accurate and consistent results of this novel technique. These systems are flexible in application and they can be used in process lines instead of human inspection. The study showed that the images of beans under UV light can be used in the separation of healthy and damaged ones automatically by using a suitable algorithm.

Wu and Sun (2013) summarized that the color of an object could be represented by several color spaces. In the color inspection of fruits and vegetables, RGB color space, HSI (hue, saturation and intensity) space. Also, reported that the images are acquired and stored in RGB color space in most computer vision systems, and each pixel in the images is composed of three integers which represent the intensity values of red, green and blue wavelengths. RGB color space is one of the most widely used color spaces in the color inspection tasks.

Hemender et al. (2018) explained that the term “image analysis” refers to the extraction of numerical data from an acquired image. Machine Vision System is a computerized apparatus designed for Image Analysis (IA), which functions similar to human observations. Fundamental approach in this technique is the acquisition of data (shape, size, color, etc.) via a video or still camera followed by analysis of these data using suitable computer software. Image Analysis shows many important advantages over manual techniques. It provides rapid analysis compared to any conventional method. Seeds are not subjected to any kind of treatment or damage. Once the system that works has been designed, then the whole process can be automated. Imaging software provides an increasingly interactive and user-friendly environment to work. After the initial outlay for equipment and research, unlike other systems, IA has few additional costs.

Logegaray et al. (2009) state that the L*a*b* color system as it is similar to how the ganglion cells in the human eye sense the amount of green or red, the amount of blue or yellow, and the amount of lightness or darkness. The L*a*b* color system uses three axes to describe color: the L* values run on the z-axis with 100 being perfect white and 0 being perfect black, the a* values run on the x-axis with positive values being more red and negative values being more green, and the b* values run on the y-axis with positive values being more yellow and negative values being more blue.

2.8. Post harvest:

GRDC (2018) state that samples with high numbers of snails will require cleaning. These steps can remove high numbers of snails with very little grain loss:

• Scalping. • Use a soft snail-crushing roller on faba bean of 14–15% MC and with a roller clearance of less than half the width of the seed.,• Screening: Gravity separation may be effective for grain coming out of storage as dead snails are lighter in weight.

2.9.Storage time:

(IIRR, 1992) Seeds, even if adequately protected during storage, still undergo deterioration with time. Major factors affecting longevity (Iife-span) of mature, viable and healthy seeds are moisture, storage temperature and pests. Most seeds are drying-tolerant (orthodox). Under ordinary room conditions (open storage), the viability of these seeds is generally reduced by half within six months. Seeds with harder seed coats tend to live longer than those with thin coats. For improved storability, seed moisture and storage temperature must be kept low and controlled.

Hang et al., (1996) reported that seeds are dried below this value.

Long-term storage: The storage of seed accession for long-term periods (a decade at a minimum or more). Stores operated at subzero temperatures are generally classed as long-term seed stores. Medium-term storage: The storage of seed for medium-term periods as is often used for active collections in genebanks or by plant breeders and seedsmen. Under the same conditions of storage, the seeds of different species will have different periods of longevity.

Thus, it is difficult to define precisely the period envisaged by 'medium-term'. A period of 2–10 years or so is assumed.

Hashem and Risha (1999) found that losses in faba bean caused by Callosobruchus maculatus are assessed in three different commercial faba bean cultivars ('Giza 716', 'Giza 461' and 'Giza 3') using the count and weight method. After about 4 months of the storage period, the percentage of infestation reached 100 % for all tested cultivars. The significant losses in dry weight (13.2 %) were found after 4 months in 'Giza 461' (most susceptible cultivar) followed by 'Giza 716' (4.6 %) and the lowest loss was in 'Giza 3' (1.7 %). The infested faba bean from all cultivars was exposed to four modified atmospheres at different exposure periods. The modified atmosphere, which contained 85 % CO_2, was the most efficient at 3 days exposure. This atmosphere was lethal for all stages of maculatus and after treatment; the seeds were free from infestation. The second efficient modified atmosphere contained 75 % CO_2 at 5 days exposure. The atmospheres, containing 50% and 35% CO_2, were not sufficient to prevent infestation, even when the exposure period was extended to 7 and 10 days.

Catholic Relief Services (2014) state that for the life of a seed largely revolves around its moisture content, the MC of the seed as it is placed in storage and the relative humidity of the store are the most important factors influencing seed viability during storage. Before placing seeds in storage, they should be dried to a safe moisture limit, although this varies considerably by crop. Very low MC below 4% may also damage seeds, due to extreme desiccation. At lower levels of humidity, seeds can be stored for longer periods. It was suggested as a rule of thumb that for every 1% reduction in seed MC the life of the seed doubles. This rule applies to moisture contents of 5–14%.

2.10. Over view:

Egyptians prefer "faba bean" as a basic meal on the table of Ramadan suhour, The Egyptian family does not dispense with it daily at the dining table, due to their reasonable prices and multiple nutritional benefits. According to medical studies faba beans are rich in proteins, vitamins and mineral salts, such as iron and phosphorus, and it also resists the stress and stress that affect the body because it contains protein and some vitamins, which makes it suitable to supply the body with the energy required during fasting hours.

According to data for 2018, Egyptians consume beans annually, between 650 to 750 thousand tons per year, and the daily consumption volume reaches 2500 tons, while Egyptians' consumption of beans during one day in the month of Ramadan reaches 10 thousand tons.The ancient Egyptians used it as a substitute for protein, and it is the first popular dish in Egypt that is presented in more than one different way, but it depends entirely on beans mixed with lemon juice and some spices of salt and cumin, and some may add to it some additions such as garlic, onions or any other flavor they prefer.

The pharaohs were the first to "braise the faba beans" and make "besara" and “falafel” as well, and he used to eat the faba bean in the general public.

Nearly 30% of legume damage was lost during handling and after harvest. Protecting stored agricultural products from insect attack is essential to providing a safe and steady supply of high-quality food to preserve germination capacity, vitality and seed activity.

Grain quality is at its highest when first loaded into storage, but can steadily deteriorate if the storage environment is not well managed. So it was necessary to use techniques to extend the shelf-life of faba bean, reduce the losses of seeds during the storage period

3. MATERIALS AND METHODS

3. MATERIAL AND METHODS

The experiments were started in spring (May, 2018) located in Giza governorate (Agricultural Engineering Research Institute) by setup and constructed the system and irradiation by Ultraviolet-C and irradiation by Laser in Laser Application in Agricultural Engineering –National Institute of Laser Enhanced Science - Cairo University, Egypt.

3.1 Materials:

3.1.1. Seed plants:

Faba bean (Viciafaba) Giza 716 variety it is Hybridized category and characterized as resistance to diseases of brown spots and rust. It cultivated in Dakahlia, some central and southern governorates of the Delta, Nubariah. It begins to bloom after 55 - 50 day from planting. The seed color with black - medium - sized navel, weighing 100 seeds from 80 - 85 grams Fig. (3–1).

Fig. 3- 1: Faba bean seeds

3.1.2. Setup of Laser.

It was located in the laboratory of Laser application in Agricultural Engineering- National Institute of Laser Enhanced Science, Cairo University, Egypt. It consists of laser source, lenses, holders, detector and beam expander, as shown in Fig.(3-2).

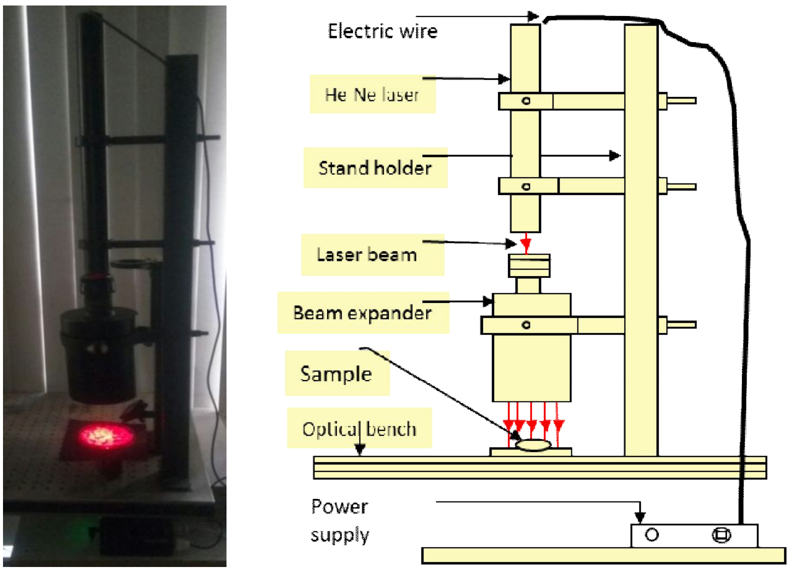


Fig. 3-2: Setup and experiment diagram of laser.

3.1.2.1.Laser source and lenses:

As a source of radiation, we used a Helium-Neon gas laser (He-Ne) with an output power of 8mW and 632.8 nm wavelength the specification shown in

Table 3-1. The laser attached with convex silica lens with 75mm diameter and 100mmfocal length

Table 3-1: The specification of He-Ne laser.

Item	Specification
Source of manufacture	USA
Model	05-LHP-151
Type	Gas laser
Wavelength (nm)	632.8
Mode	Continuous wave
Output power(mW)	8
Beam diameter(mm)	1
Beam divergence (mrad)	0.62
Polarization ratio	Random
Weight (kg)	0.61
In put current (Ac) , (AMP)	220 , 3
Operating temperature (^{o}C)	-20 : + 50
Storage temperature (^{o}C)	-40 : + 80

3.1.2.2.Beam expander

The reverse Galilean telescope design provides a certain angular magnification, called the Expander Power. The beam diameter is first increased in size by its power. The expander was used in the optical unit in front of Laser. The specifications of the beam expander were as follows:

- Dimensions of the expander with length of 280 mm, maximum and minimum diameters of 110 and 50 mm.
- Source of manufacture: Egypt made in hard Aluminum, electrostatic black paint.
- Beam expansion power : 50 X
- Lenses: 1 st Diverging lens : F = 20 mm; Dia.= 15 mm;

  2 nd Diverging lens: F = 2.2 mm; Dia. = 10 mm;

  Collimating lens : F = 240 mm; Dia. = 100 mm

  (F is the focal lens)

Description of the apparatus, the opto- electronic apparatus was manufactured and developed to provide irradiation faba bean seeds samples with different doses. The opto – electronic apparatus are shown in Fig. (3-2) consists of the following main parts: Stand holder, it was designed and fabricated of iron as a shape square with length 45 mm and total length 900 mm , it contain seven holes to adjust the height and direction of laser and beam expender to insure a good aliment of helium-neon laser beam on measurement area. The stand holder was fixed as a vertical on optical bench by two screw bolts.

The optical bench was fabricated from stainless steel. The dimensions of this bench were 880, 580 and 45 mm for length, width and height, respectively, with screw holes 6 mm diameter and the distance between them was 50 mm. Bench was manufactured in USA sitting on the second frame.

3.1.3. Ultraviolet unit:

Ultraviolet unit was consists of UVC lamps, box, timer (time controller), electrical wire and tray as the following:

3.1.3.1.UVC Lamps:

UVC light treatment was carried out in a lab scale by using two germicidal lamps (HRA 4384 Germany) emitting UVC at 253.7 nm and 2.5cm diameter were placed on top of Aluminum box. Each lamp (with 60 cm tube length) had a nominal power output of 18W as shown in Fig (3-3).

Fig. 3- 3: UVC lamps

3.1.3.2.UVC box:

The box was constructed from Aluminum metal (90x45x45cm), covered with reflective materials (Aluminum paper) to increase the UV-C intensity and minimize the shadow effect.

3.1.3.3.Tray:

A stainless steel sample holding tray with dimensions (70x30 cm), and it covered with reflective materials (Aluminum paper) to increase the light intensity and minimize the shadow effect. It was used to place the samples at 30cm from the lamps, as shown in Figs (3-4 and 3-5).

Fig. 3- 4: UVC box

Fig. 3-5: Holding tray

3.1.4. Instruments:

3.1.4.1.Time switch:

Switch time 24 hours was attached with Aluminum box to control the irradiation time. The switch was 250W (220-240V, 50Hz).

3.1.4.2.UVA and UVC light meter:

UVC irradiance during the treatments was measured at the surface of the samples using a UVA and UVC light meter (YK- 37UVSD).

3.1.4.3.Digital force gauge:

The Digital force gauge model: FGN-50 was used to measure penetration resistance and shear strength for ±500 N with accuracy ±0.2%.

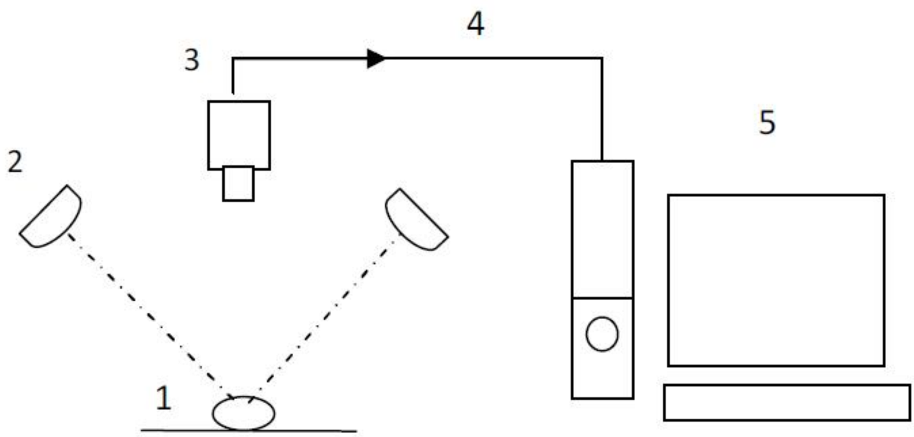
3.1.4.4.Dial-micrometer:

The length, width and thickness of materials were measured by a dial-micrometer to an accuracy of 0.01 mm.

3.1.4.5. Digital camera and illumination system:

A digital CCD camera and illumination system was used to take photo images for different stages of storage seed, as shown in Fig.(3-6).

a- Setup of illumination system.



b- Vision and color analysis systems.

1- Faba bean sample 2-light source 3- Digital camera

4- Electric wire 5-Personal computer

Fig. 3-6: Vision, illumination and color analysis systems.

Table 3-2: Specifications of illumination system.

Model	Hama Reporo
Source of manufacture	Germany
No. of lamps	4
Lamp type	Ordinary
Light color of lamp	White
Lamp Power, W	100
Power supply electricity, Volt	220
Area image (DIN)	A3, A4, and A5
Length of stand, cm	73
Light incident angle, rad (deg).	45

3.2.Methods:

3.2.1. Seed of plants:

Faba bean seeds which used in this study were provided from (Field Crops Research Institute - ARC). The seeds quantities were used 3kg/treatment.

3.2.2. Physical and mechanical characteristics:

3.2.2.1. Seed dimensions:

Seeds number (n= 100) were tested for mean seed dimensions (cm) the length, width, thickness of faba bean grains were measured in randomly selected 100 faba bean seeds, using a digital-vernier caliper.

3.2.2.4. Seed weight:

To get the unit mass of the seed, a hundred seed's mass was measured randomly seed selected by using digital balance, the average mass of 100-seed was calculated from 4 replicates (100-seed each) in grams.

3.2.2.5. Seed hardness:

The maximum force to penetrate and shear compress seeds were measure by Digital force gauge in Newtons (N) was determined to represent seed hardness.

3.2.3. Chemical characteristics:

Three seed samples from each treatment were collected to determined percentage of Moisture content of seed, Ash, Protein, Carbohydrate, Fiber and Fat were done using the (A.O.A.C. 2000) procedure.

3.2.3.1. Moisture content:

$$M.C.\ \% = 100\ (W_1 - W_2)/W_1 \text{---------------------------(1)}$$

M.C. %:Moisture content (%)

W_1: Weight of sample before drying (g)

W_2: Weight of sample before drying (g)

3.2.4.2. Ash content:

$$Ash(\%) = \frac{\text{Weight of ash,g}}{\text{weight of sample,g}} \times 100 \text{-------------(2)}$$

3.2.3.3. Protein content:

Total nitrogen was determined using the micro –Kjeldahl methods outlined in AOAC(200) methods. Percentage nitrogen was multiplied by 6.25 to obtain percentage protein

3.2.3.4. Fiber content:

$$Fiber\ content(\%) = \frac{W_2 - W_1}{W_s} \times 100 \text{-------------(3)}$$

Where:
W_1 = Weight of crucible before ashing, g
W_2 = Weight of crucible after ashing, g
W_s= Weight of sample, g

3.2.4.5. Fat content:

$$Fat(\%) = \frac{\text{Weight of Fat,g}}{\text{weight of sample,g}} \times 100 \text{--------------(4)}$$

3.2.3.6. Carbohydrate content:

Carbohydrate = 100-(Moisture content%+ Ash%+ Protein%+ Fiber%+ Fat%)--(5)

3.2.4. Microbial characteristics:

Determine total viable count (TVC) was gives a quantitative estimate of the concentration of microorganisms (bacteria) in a sample. The count represents the number of colony forming units (cfu) per g (or per ml) of the sample.(ISO- 4833-1:2013 and 7218:2007 E.)

3.2.5. Color characteristics:

Samples were analyzed for changes in seed color. The color and data collection for the values of Cielab scale parameters (L, a* and b*) were L represents Lighteness, a* and b* indicate red-green and yellow-blue, respectively determined by 10 randomly selected seeds and 4 replicas for the first face and 4 replicates for this other side for each seed.

3.2.6. Experimental description:

The experimental study was including three treatment factors as, UV-irradiation and Laser irradiation time duration treatments. Irradiation treatments have three doses of Ultraviolet irradiation, three times of Laser irradiation and sample without irradiation (control). While time duration was 30, 60 and 90 min for Ultraviolet treatment **corresponding with Faruki et al. (2007)** use UVC for different durations to determine irradiation effects on egg-hatching and adult emergence for 2, 4, 8, 16, and 24 min meanwhile, 15, 30 and 45 min for laser treatment and 0 min for treatment without irradiation according to **Mistry and Keshatti (2017)** who exposed the soybean seeds to a He-Ne laser with a wavelength 632.8 nm for 0, 5, 10, 15, and 20 min and **Yasemin et al. (2013)** investigated the effect of He-Ne laser on wheat seeds which were irradiated to 1, 5, 10, 15 min while **Abu-Elsaoud et al. (2008)** irradiated wheat Seeds with IR laser for 0, 1, 3, 10, 30, 60, 180, 600, 1200, and 1800 sec. The experimental lay out showed in Table 3-3.

3.2.7. Calculate doses for UV-C and laser:

The dose was calculated according to Bachmann (1975) as shown in the equation (6):

$$D = L \times T \text{------------------------}(10)$$

D = applied dosage (mJ/cm^2), L = applied intensity (mW/cm^2) and T = exposure time (Sec).

The laser exposure times were 0, 15, 30 and 45 minute and intensity was 0.073mW/cm^2, so the applied doses were 0 (as a control), 65.7, 131.4 and 197.1 mJ/cm^2 respectively. Meanwhile, The UV-C exposure time durations were 0, 30, 60 and 90 minute and intensity was 2.38 mW/cm^2, So the applied doses were 0 (as a control), 4.28x10^3 , 8.56 x10^3, 12.85x10^3 mJ/cm^{2}respectively.

3.2.8. Storage treatment:

After exposure by Laser and UV-C light, each sample was placed in a woven plastic bag as shown in Fig 3-7 and table 3-3 (according to the Egyptian standards specification for woven polyethylene and polypropylene Es: 1575/2007) and stored under normal condition without total or partial vacuum for nine months at room temperature. Four samples are taken from each treatment every three months and determined Physical, mechanical, chemical, microbial and optical analysis changes to observation the changes that occur during storage period.

Table 3-3: Specifications of woven polyethylene with high density.

Thread width	2.4 ±0.1 mm
Thread thickness	45-65 μm
Thread accuracy	1000
Tensile strength	3 Kg
Bag storage temperature	25 ±5^{o} C
humidity	65%

Fig. 3-7: woven polyethylene

3.2.9. Statistic analysis:

A specialist statistical program (SPSS, Ver. 20) used to analyze the simple linear regression between the dependent and independent variables for faba bean seed.

Table 3-4: Experimental layout

Irradiation treatment	**Time duration**	**Replication**
I_0	T_0	R_1
		R_2
		R_3
		R_4
I_1	T_1	R_1
		R_2
		R_3
		R_4
	T_2	R_1
		R_2
		R_3
		R_4
	T_3	R_1
		R_2
		R_3
		R_4
I_2	T_4	R_1
		R_2
		R_3
		R_4
	T_5	R_1
		R_2
		R_3
		R_4
	T_6	R_1
		R_2
		R_3
		R_4

I_0= without irradiation (control) I_1= Ultraviolet irradiation

I_2= Laser irradiation

T_0=0 min T_1=30 min T_2=60 min T_3=90 min

T_4=15 min T_5=30 min T_6=45 min

R_1, R_2, $R_3$and R_4= Replicates

4. RESULTS AND DISCUSSION

4- RESULTS AND DISCUSSION

4.1. Physical properties of faba bean:

4.1.1. Effect of laser exposure and UVC irradiation time on principal dimensions of faba bean during storage periods :

An average of the three principal dimensions (length, width and thickness) of faba bean seeds were indicated in Table (4-1) by using laser exposure time (15, 30 and 45 min.) and (0 min.) treatment without irradiation, during storage periods of 0,3,6 and 9 months.

While Table (4-2) Show the effect of UVC irradiation times (30, 60 and 90 min.) and (0 min.) treatment without irradiation, during storage periods of 0, 3, 6 and 9 months.

Table (4-1) high lighted that length dimensions decreased by increased storage periods. The initial lengths at 0 months were 16.17, 16.18, 16.19and 16.19 mm and they were 15.6, 15.69, 15.74 and 14.72 mm after 9months for 15, 30, 45 min.. and 0 min.. (control) for laser exposure time, respectively.

And also Illustrated that the width was increased by decreasing the storage time. The highest width values at 0 months were 12.13 and 12.13mm can be achieved for (0 and 45 min.), and 12.1, 12.09 mm for (30 and 15 min.), respectively, and the lowest width values were 11.33, 11.96, 11.78 and 11.67mm for (control, 45, 30 and 15 min.), respectively.

From the results introduced in Table (4-1), it could be observed that the thickness reduction values range from (0 month) to (9 months) were (5.73 – 5.46mm) and (5.76- 5.47 mm) can be achieved for (15 and 30min.), while (5.79-5.62mm) and (5.80-5.31mm) for (45 and 0min.), respectively.

Table (4-1): Effect of laser exposure time on principal dimensions of Faba bean during storage.

Storage period (Months)	Laser exposure time (min.)			
	0	15	30	45
Length (mm)				
0	16.19	16.17	16.18	16.19
3	15.56	15.90	15.94	15.95
6	15.33	15.62	15.72	15.87
9	14.72	15.60	15.69	15.74
SD*	0.61	0.27	0.23	0.19
Width (mm)				
0	12.13	12.09	12.10	12.13
3	11.69	11.89	11.99	12.08
6	11.46	11.74	11.84	12.00
9	11.33	11.67	11.78	11.96
SD	0.35	0.19	0.15	0.08
Thickness (mm)				
0	5.80	5.73	5.76	5.79
3	5.49	5.61	5.64	5.70
6	5.44	5.55	5.58	5.66
9	5.31	5.46	5.47	5.62
SD	0.21	0.11	0.12	0.07

SD*= Standard Deviation

Table (4-2): Effect of UVC irradiation times on principal dimensions of Faba bean during storage.

Storage period (Months)	UVC irradiation times (min.)			
	0	30	60	90
Length (mm)				
0	16.19	16.09	16.10	16.12
3	15.56	15.62	15.75	15.86
6	15.33	15.41	15.55	15.70
9	14.72	14.79	14.99	15.48
SD	0.61	0.54	0.46	0.27
Width (mm)				
0	12.13	12.00	12.02	12.06
3	11.69	11.66	11.71	11.83
6	11.46	11.59	11.68	11.77
9	11.33	11.55	11.63	11.65
SD	0.35	0.21	0.18	0.17
Thickness (mm)				
0	5.80	5.59	5.63	5.66
3	5.49	5.50	5.53	5.56
6	5.44	5.44	5.47	5.5
9	5.31	5.35	5.40	5.48
SD	0.21	0.10	0.10	0.08

Table (4-2) illustrated that length dimensions decreased by increased storage periods and decreasing the irradiation times. The initial lengths at 0 months were 16.19,16.09,16.1and 16.12 mm and they were 14.72,14.79,14.99 and 15.48 mm after 9 months for 30, 60, 90min. and 0min. (control) for UVC irradiation times, respectively.

Also, indicated that the width was increased by decreasing the storage period and increasing the irradiation times. The highest width at 0 months were

12.13 and 12.06mm can be achieved for (0 and 90min.), and 12.02, 12.00mm for (60 and 30min.), respectively, and the lowest width value were 11.33, 11.65, 11.63 and 11.55mm for (control, 90, 60 and 30min.), respectively.
From the results introduced in Table (4-2), it could be observed that the thickness reduction value ranged from (0month) to (9months) were (5.80-5.31) and (5.59 – 5.35mm) can be achieved for (0 and 30min.), while (5.63-5.40mm) and (5.66-5.48mm mm) for (60 and 90min.), respectively.

Similar results of increased in the physical properties with moisture content are reported by **Tavakoli et al. (2009)** who evaluated the effect of four levels of moisture content ranging from 6.92 to 21.19% dry basis (db) on some physical properties behavior under compression load of soybean grains. Increased the average width, length, thickness, geometric mean diameter, arithmetic, angle of repose surface area and thousand-grain mass by increasing moisture content from 6.92 to 21.19%.

The present experiments confirm with previous results **Shoughy and Amer (2006)** evaluated the physical and mechanical properties of three different varieties of faba bean seeds as a function of moisture content. The average length of faba bean seeds decreased from 16.46 to13.55mm, from 20.91 to 18.49mm and from 22.24 to 20.52mm; the width decreased from 13.23 to10.69mm, from 15.53 to13.26mm and from 16.82 to14.99mm; the thickness from 8.42 to 6.29mm, from 9.32 to7.51 mm and from 16.82 to14.99mm for medium1, medium2 and large-seeds, respectively as the moisture content decreased from 26.5 to 9.8%. **Altuntas and Yıldız (2007)** studied the effect of moisture content on some physical properties and mechanical behavior for faba bean grains. The average width, length and thickness ranged from 13.66 to 12.54mm, 19.77 to 18.40mm, and 8.03 to 7.00 mm, respectively. And the unit mass of grain, grain volume, sphericity, thousand-grain mass, angle of repose and true density of faba bean grains decreased from1.301 to 1.147g, 1.099 to 0.998 Cm^3, 1332.67 to 1140.15g, 1206.21 to 1151.33 kgm^{-3} , respectively as the moisture content decreased from 25.08 to 9.89% db The results are in line with **Bamgboye and Adebayo (2012)** have been examined The moisture-dependent physical and mechanical properties of Jatropha curcas were studied. Five levels of moisture content ranging from 5.85 to 25.85 % db were used. Standard methods were used to determine physical properties. The average length, width, thickness, thousand grains mass increased as the moisture content.

Gezer et al. (2003) evaluated the physical properties of pits and kernels of Hacıhaliloğluapricots as a function of moisture content varying from 6.79 to 36.19% db for apricot pits and from 6.95 to 38.76% db for apricot kernels.The dimensional properties and weight of apricot pit and apricot kernel increased depending on moisture content. In apricot pit and apricot kernel; 1000 grain weight, grain volume, true density, and projected area increased with moisture content. **Fathollahzadeh et al. (2008)** evaluated the physical properties of apricot kernels as a function of moisture content. With increasing in moisture content, kernel length, width, thickness, geometric mean diameter and surface area increased. While the porosity and bulk density was decreased. The results are also consistent with **Altuntas and Demirtola (2007)**

4.1.2. Effect of laser exposure and UVC irradiation time on mass, volume and density of faba bean during storage periods :

An average of the mass, volume and density of faba bean seeds were indicated in Table (4-3 and 4) by using laser exposure and UVC irradiation time during storage periods of 0,3,6 and 9 months.

Table (4-3) indicated that mass decreased by increasing storage periods. The lowest values of mass were (79.09 and 83.18g) for (0 and 15min.). While they were (83.46 and 85g) after 9months for treatment (30, 45min.), respectively.

And also indicated that bulk volume and true volume decreased by increasing storage periods. The lowest values after 9 months were (67.18 and 126 cm^3) and (71.96 and 144 cm^3) for (0 and 15min.). While they were (74.87 and 145cm^3) and (76.53 and 149 cm^3) after 9 months for treatment (30, 45min.), respectively.

Table: (4-3): Effect of laser exposure time on mass, volume and density of Faba bean during storage.

Storage period (Months)	Laser exposure time (min.)			
	0	15	30	45
Mass (g)				
0	85.5	85.33	85.43	85.5
3	81.40	84.19	84.23	85.39
6	80.68	83.47	83.53	85.25
9	79.09	83.18	83.46	85.00
SD	2.73	0.96	0.91	0.22
True Volume (cm^3)				
0	155	151.72	152.42	155
3	147.57	149.69	150.28	154.8
6	131.63	147.5	147.12	149.44
9	126	144	145	149
SD	13.52	3.30	3.29	3.29
Bulk Volume (cm^3)				
0	77.89	75.92	77.45	77.76
3	74.15	74.73	76.23	76.88
6	71.95	72.31	75.03	76.75
9	67.18	71.96	74.87	76.53
SD	4.47	1.91	1.20	0.54
True density (g/cm^3)				
0	0.55	0.56	0.56	0.55
3	0.55	0.56	0.56	0.55
6	0.61	0.57	0.57	0.57
9	0.63	0.58	0.58	0.57
SD	0.04	0.01	0.01	0.01
Bulk density (g/cm^3)				
0	1.098	1.124	1.103	1.100
3	1.098	1.127	1.105	1.111
6	1.121	1.154	1.113	1.111
9	1.177	1.156	1.115	1.111
SD	0.04	0.02	0.01	0.01

Table (4-4): Effect of UVC irradiation times on mass, volume and density of Faba bean during storage.

Storage period (Months)	UVC irradiation times (min.)			
	0	30	60	90
Mass (g)				
0	85.50	85.00	85.10	85.26
3	81.4	83.46	84.03	84.11
6	80.68	81.97	83.21	83.33
9	79.09	79.74	82.55	82.68
SD	2.73	2.24	1.10	1.11
True Volume (cm^3)				
0	155.00	149.58	150.17	151.37
3	147.57	146.87	148.28	149.33
6	131.63	133.64	134.08	141.10
9	126.00	129.00	135.00	140.00
SD	13.52	10.00	8.52	5.74
Bulk Volume (cm^3)				
0	77.89	73.52	73.79	74.89
3	74.15	72.21	72.77	72.9
6	71.95	70.73	71.06	71.26
9	67.18	68.49	70.09	70.5
SD	4.47	2.16	1.66	1.95
True density (g/cm^3)				
0	0.55	0.57	0.57	0.56
3	0.55	0.57	0.57	0.56
6	0.61	0.61	0.62	0.59
9	0.63	0.62	0.61	0.59
SD	0.04	0.03	0.03	0.02
Bulk density (g/cm^3)				
0	1.098	1.156	1.153	1.138
3	1.098	1.156	1.155	1.154
6	1.121	1.159	1.171	1.169
9	1.177	1.164	1.178	1.173
SD	0.04	0.00	0.01	0.02

Meanwhile Table (4-4) indicated that mass and bulk volume decreased by increasing storage periods and decreasing irradiation times. The lowest values of mass and bulk volume were (79.09g, 67.18 cm^3 and 79.74g, 68.49cm^3) for (0 and 30 min.). Meanwhile, they were (82.55g, 70.09 cm^3 and 82.68g, 70.5 cm^3) after 9 months for treatment (60 and 90min.), respectively.

From the results introduced in Table (3 and 4), it could be observed that the bulk density and true density increased by the increasing storage period.

Shoughy and Amer (2006) evaluated the physical and mechanical properties of faba bean seeds as a function of moisture content in the range of 9.8 to 26.5% (dry basis, d.b.). The volume of the seed and thousand seed mass was linearly increased. While, the bulk and true densities have a negative relationship with moisture content.

Altuntas and Yıldız (2007) determined the effect of moisture content on some physical properties and mechanical behavior for faba bean grains. They found that as the moisture content decreased from 25.08% to 9.89%d.b. The bulk density increased from 381.6 to 419.59kgm^{-3}.

Yalçın et al. (2007) the physical properties of pea seeds were evaluated as a function of moisture content. They found that by decreasing the moisture content from 35.08 to 10.06%d.b. The true and bulk densities were increased.

Gezer et al. (2003) evaluated the physical properties of pits and kernels of Hacıhaliloğlu apricots as a function of moisture content. The bulk density value increased with moisture content in the apricot pit, there was a negative relationship in the apricot kernel.

4.2. Mechanical properties of faba bean:

4.2.1. Effect of laser exposure and UVC irradiation time on shear force of faba bean during storage periods :

Fig. (4-1 and 2) shows the effect of laser exposure and UVC irradiation time on the shear force of faba bean during storage periods.

Fig. 4-1 it was indicated that shear force was increased as the storage periods increase. Meanwhile, the shear force decreased with increasing laser exposure time. The initial shear force at 0 months were 318.3, 308.8, 287.0 and 371.6N and they were 582.1, 550.4, 503.9 and 597.0N after 9months for 15, 30, 45min. And 0min. (control) for laser exposure time, respectively. While SD for treatments were 99.44, 111.08, 101.71 and 91.50 for (0,15,30 and 45min), respectively.

Fig. (4-2) shows the effect of UVC irradiation times on shear force of faba bean during storage periods. It was indicated that shear force was increased as the storage periods increase. Meanwhile, the shear force increased by decreasing UVC irradiation times. The shear forces at 0 months were 371.6 and 365.8N can be achieved for (0 and 30min.), and 357.7, 343.4N for (60 and 90min.), respectively, and the highest shear force were 597,596.9, 593.9 and 590.9N for (0, 30, 60 and 90min.), respectively. While SD for treatments were 99.44, 101.09, 99.4 and 104.87 for (0,30,60 and 90min), respectively.

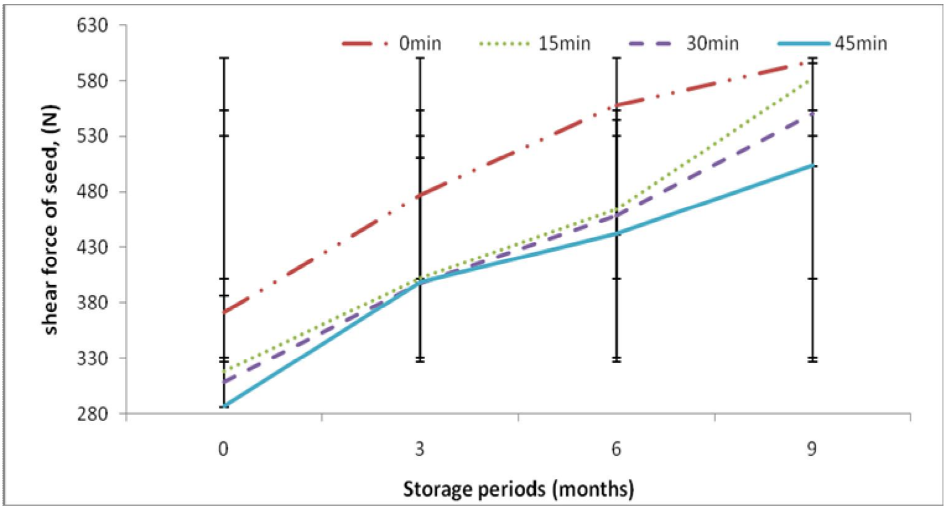


Fig. (4-1): Effect of laser exposure time on the shear force of Faba bean seeds.

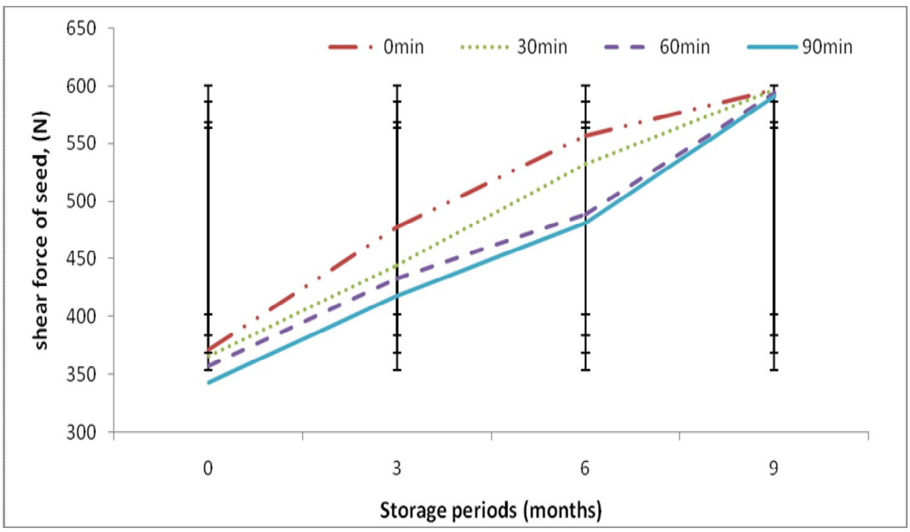


Fig. (4-2): Effect of UVC irradiation on the shear force of Faba bean seeds during storage.

4.2.2. Effect of laser exposure and UVC irradiation time on penetration force of faba bean during storage periods :

Fig. (4-3 and 4) illustrated the effect of laser exposure and UVC irradiation time on the penetration force of faba bean during storage periods.

It was indicated from Fig. (4-3) that the Penetration force was increased as storage periods increased. Meanwhile, the Penetration force was found to decrease with increasing laser exposure time. The highest penetration force at 0 months was 576.1 and 490.1N can be achieved for (0 and 15min.), and 480.9, 463.3N for (30 and 45min.), respectively, and the lowest Penetration force were 358.8, 264.1, 273.9 and 282.7N for (control, 45, 30 and 15min.), respectively. While SD for treatments were 95.69, 93.79, 93.80 and 92.95 for (0,15,30 and 45min), respectively.

Fig. (4-4) illustrated the effect of UVC irradiation times on the penetrating force of faba bean during storage periods. It was indicated that the penetration force was increased as storage periods increased. Meanwhile, the penetration force was found to decrease with increasing UVC irradiation times. The initial Penetration forces at 0 months were 358.8,356.4,290.9 and 283.5 N and they were 576.1,571,543 and 510.4 N after 9 months for 0, 30, 60min and 90min. for UVC irradiation times, respectively., this results may be related to decrease the moisture content by increasing storage times.

While SD for treatments were 95.69, 95.35, 110.55 and 102.44 for (0,30,60 and 90min), respectively

These results are in good agreement with **Kingsly et al. (2006)** who reported that the hardness and toughness of pomegranate seeds decreased with increase in moisture content.

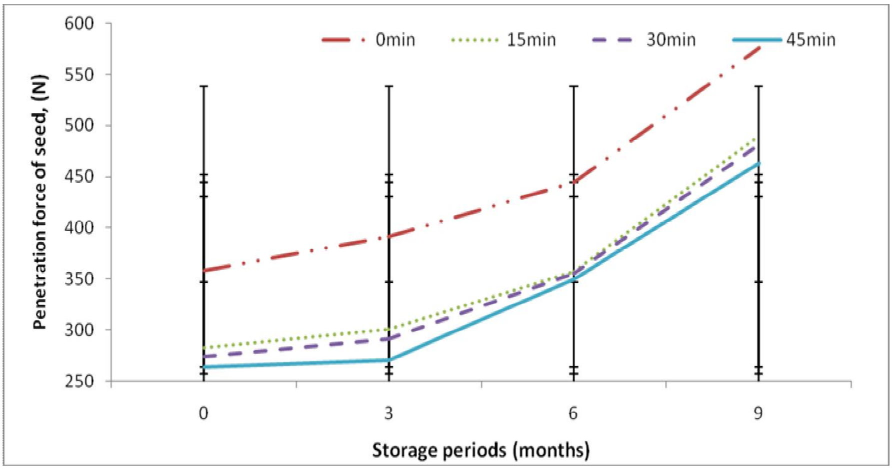


Fig. (4-3): Effect of laser exposure time on the penetration force of faba bean seeds.

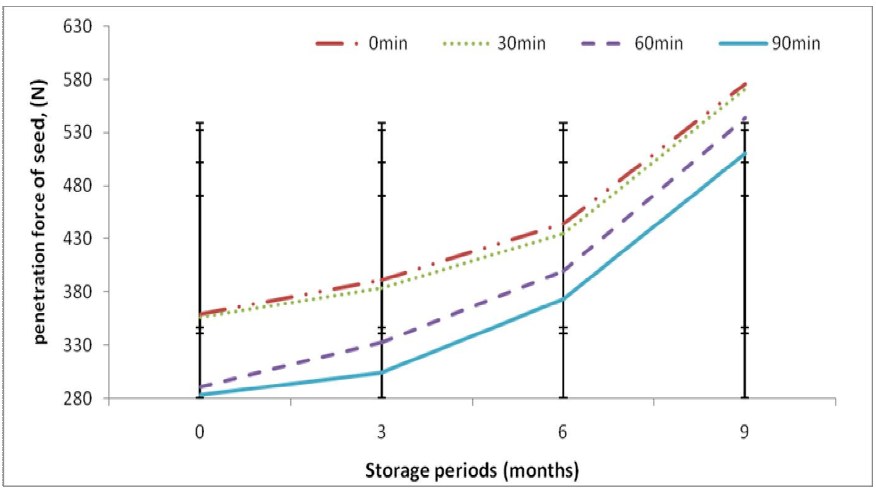


Fig. (4-4): Effect of UVC irradiation times on the penetration force of Faba bean seeds during storage.

4.3. Chemical properties of faba bean:

4.3.1. Effect of laser exposure and UVC irradiation time on protein content of faba bean during storage periods:

Fig. (4-5 and 6) illustrated the effect of laser exposure and UVC irradiation time on the protein percentage of faba bean during storage periods.

Fig. (4-5) shows the reduction in protein percentage at 15, 30, 45 min. and 0min. of laser exposure time for storage periods (0, 3, 6and 9 months). The results indicated that the highest reduction values in protein percentages at (after 9 months) were (23.22 and 22.78%) for (45 and 30 min.) and (21.92 and 20.15%) for (15 and 0 min.), respectively. While SD for treatments were 4.57, 2.29, 2.27 and 2.18 for (0,15,30 and 45min), respectively.

Fig. (4-6) illustrated the reduction in protein percentage at 0, 30, 60 min. and 90min. of UVC irradiation times for storage periods (0, 3, 6and 9 months).The results indicated that the highest reduction in protein percentages after 9 months, they were (20.15 and 21.36 %) for (0 and 30 min.) and (22.77 and 23.25%) for (60 and 90 min.), respectively. The result summarized that the protein percentage has an inverse relationship with the storage period and a positive relationship with irradiation times. While SD for treatments were 4.57, 2, 1.85 and 1.56 for (0, 30, 60 and 90min), respectively

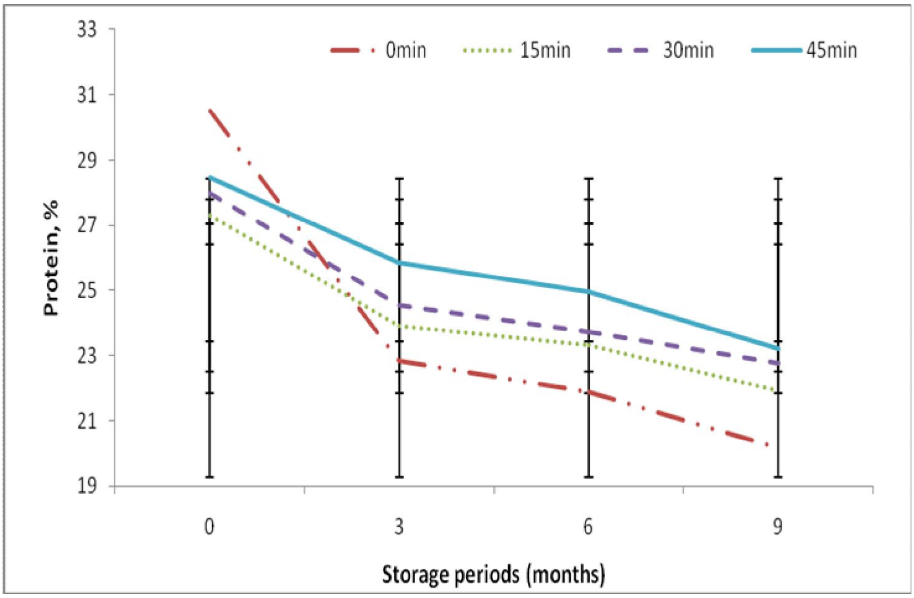


Fig. (4-5): Effect of laser exposure time on protein percentage of Faba bean during storage time

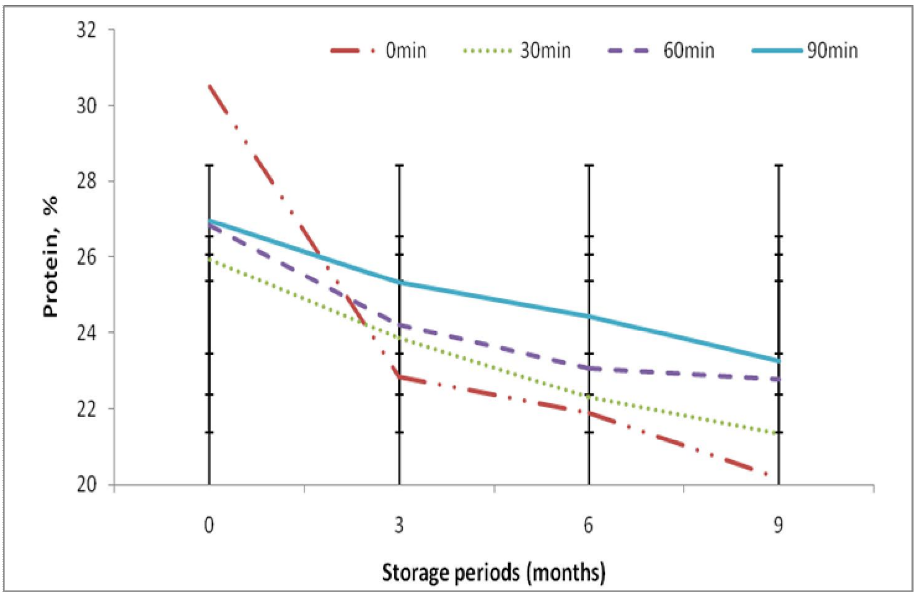


Fig. (4-6): Effect of UVC irradiation times on protein percentage of Faba bean during storage.

The results agreed with the range obtained by **Abeer et al. (2013)**, which ranged from 26.65 to 30.72%. Likewise,

Boghdady et al. (2017) also reported that the percentage of protein in faba beans ranged between 18-32%, which is consistent with the results obtained from the study. And **Stefanello et al. (2015)** they have analyzed the chemical composition of the seeds of land-races maize keeps underneath different conditions. Also, the results it had been summarized that the content of crude protein content at the top of the storage period.

El-Refai et al. (1988) stated that storage methods and periods had noticeable effects on the protein contents of all parts of Faba bean seeds. And **Gezer et al. (2003)** found that Protein content was 29.63%. While **Al-Nouri and Siddiqi (1982)** state the range of protein percentage between 24.2 - 29.2% for 12 faba bean cultivars.

4.3.2. Effect of laser exposure and UVC irradiation time on moister content of faba bean during storage periods:

Fig. (4-7 and 8) illustrated the effect of laser exposure and UVC irradiation time on the moister_content of faba bean during storage periods.

The relationship between reduction in moisture content percentage for 45, 30, 15 and 0 min. irradiation and storage period represented in Fig. (4-7) It could be found that the moisture content percentages decreased by increasing storage period. The highest reduction (after 9 months) were (9.20 and 9.17%) can be achieved for (45, 30min.) irradiation and (9.14 and 8.70%) for (15, 0min.), respectively. While SD for treatments were 0.95, 0.71, 0.72 and 0.72 for (0, 15, 30 and 45min), respectively.

Fig. (4-8) shows the reduction in moisture content percentage for 0, 30, 60 and 90min. of UVC irradiation times for storage periods of 0, 3, 6 and 9 months. It could be found that the moisture content percentages decreased by increasing the storage period and decrease irradiation times. The highest moisture content percentages (after 9 months) were (8.70 and 9%) can be decreased for (0, 30min.) irradiation and (9.11 and 9.13%) for (60, 90 min.), respectively. While SD for treatments were 0.95, 0.69, 0.67 and 0.71 for (0, 30, 60 and 90min), respectively

The results agree with the range obtained by **Abeer et al. (2013)** which ranged from 9.15 to 10.45%.

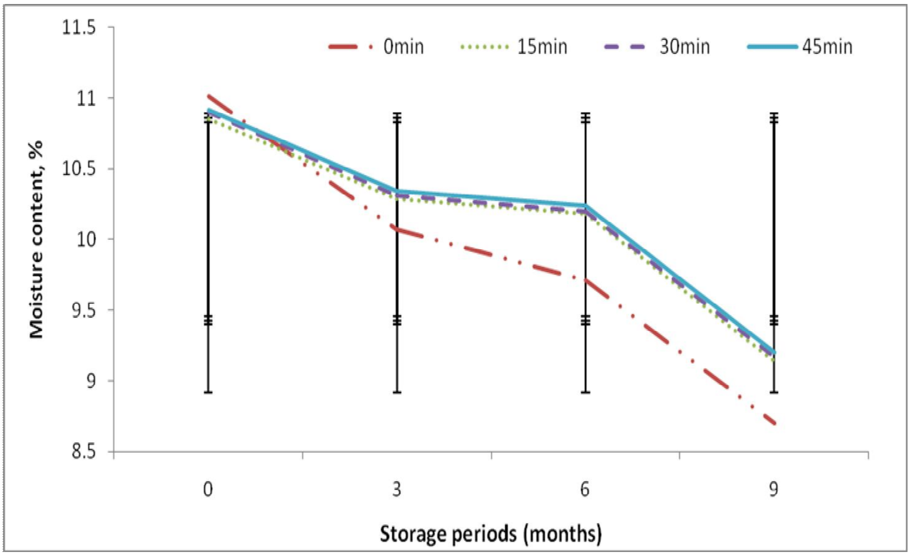


Fig. (4-7): Effect of laser exposure time on moisture percentage of Faba bean during storage time.

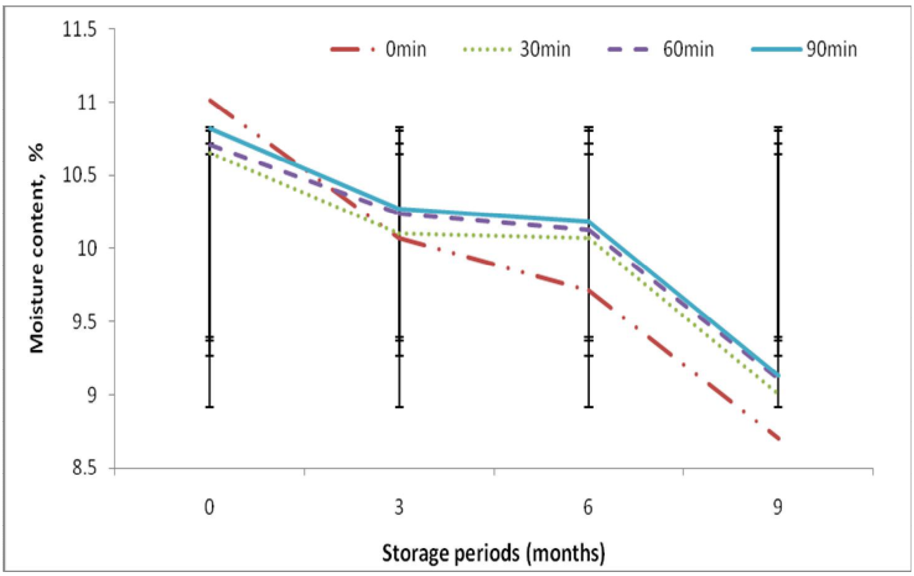


Fig. (4-8): Effect of UVC irradiation times on the moisture content of Faba bean during storage.

4.3.3. Effect of laser exposure and UVC irradiation time on fat content of faba bean during storage periods:

Figs. (4-9 and 10) illustrated the reduction in fat percentage of laser exposure and UVC irradiation time for storage periods (0, 3, 6and 9 months).

From the results introduced in Fig. (4-9), it could be observed that the fat percentage decrease range from 0 to 9 months were (3.69 - 2.00%) and (3.52- 1.95 %) can be achieved for (45 and 30 min.), while (3.50 - 1.73%) and (3.84 - 1.73%) for (15 and 0min.), respectively. While SD for treatments were 1.55, 0.78, 0.68 and 0.72 for (0,15,30 and 45min), respectively.

Fig. (4-10) shows that the fat percentage decrease range (from 0 to 9 months) was (3.84 – 0.10%) and (3.32-0.60 %) can be achieved for (0 and 30 min.), while (3.34 – 0.62%) and (3.40 - 0.71%) for (60 and 90min.), respectively. While SD for treatments were 1.55, 1.18, 1.2 and 1.2 for (0,30,60 and 90min), respectively

The results of this study are corresponding to those reported by **Abreu et al. (2013)**, working with sunflower seeds concluded that oil content in the seeds declined over time regardless of storage conditions. **Stefanello et al. (2015)** stated that the percentage of lipids of maize seeds decreased significantly at the end of the storage period, regardless of storage conditions used, And they cited the explanation of the great difference in the percentage of lipids occurs thanks to the increased consumption of reserve substance seeds, due to the occurrence of biochemical processes in seed mass. The results were higher than those found by **Abeer et al. (2013)**, which ranged from 1.93-2.05%. Also, **Boghdady et al. (2017)** reported that the fat percentage in faba beans ranged between 05-5.6%, which is agreeing with the results.

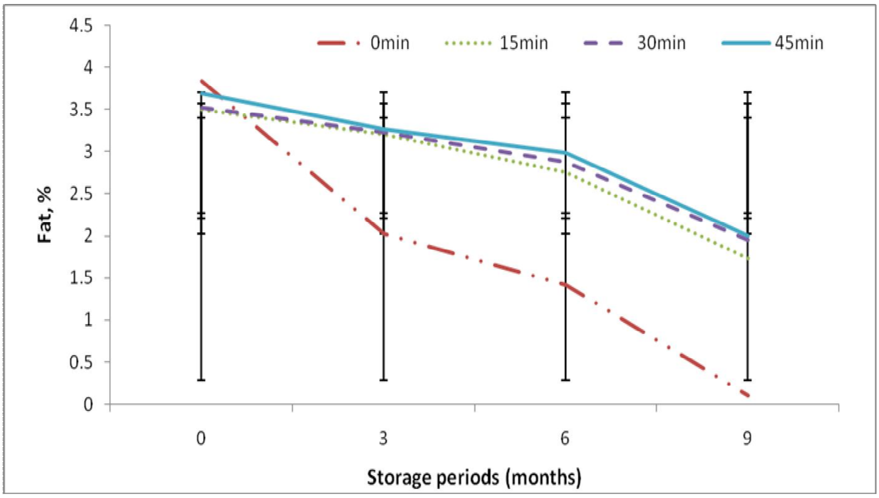


Fig. (4-9): Effect of laser exposure time on fat percentage of Faba bean during storage time.

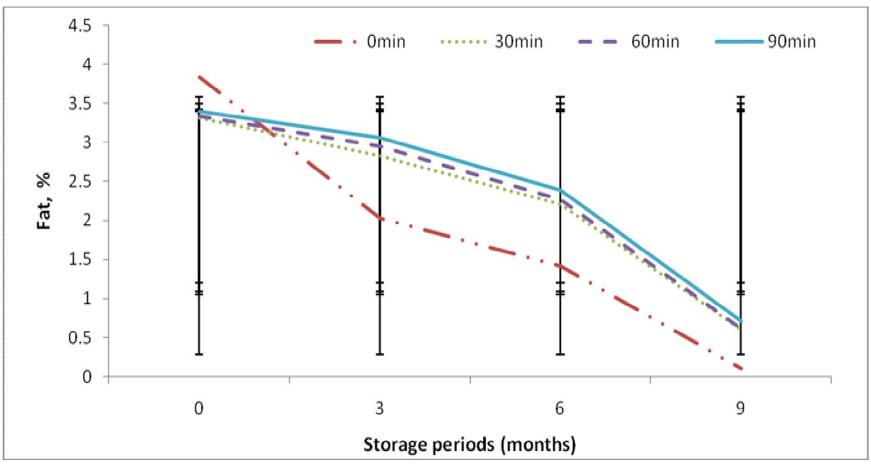


Fig. (4-10): Effect of UVC irradiation times on the fat percentage of Faba bean during storage.

4.3.4. Effect of laser exposure and UVC irradiation time on fiber content of faba bean during storage periods:

Fig. (4-11 and 12) illustrated the effect of laser exposure and UVC irradiation time on the fiber content of faba bean during storage periods.

The results presented in Fig. (4-11) Show the change in faba bean fiber percentage for treatments 45, 30, 15 and 0min. With time storage period, it could be indicated that the fiber percentage decreased with the increased storage period. The highest decreased after 9months was (8.58 and 8.30 %) can be achieved for (45, 30min.) and (7.99 and 7.14%) for treatments (15, 0min.), respectively. While SD for treatments were 1.89, 1.49, 1.45 and 1.24 for (0,15,30 and 45min), respectively.

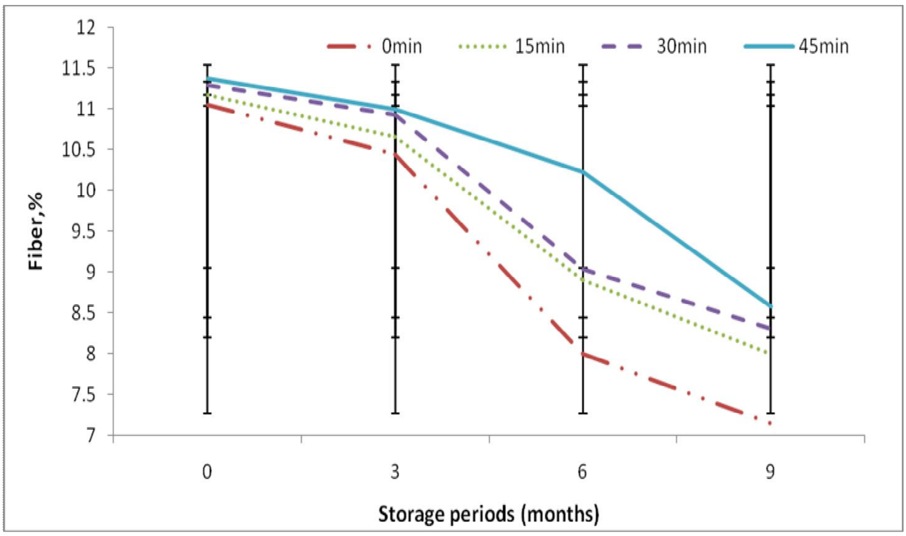


Fig. (4-11): Effect of laser exposure time on fiber percentage of Faba bean during storage time.

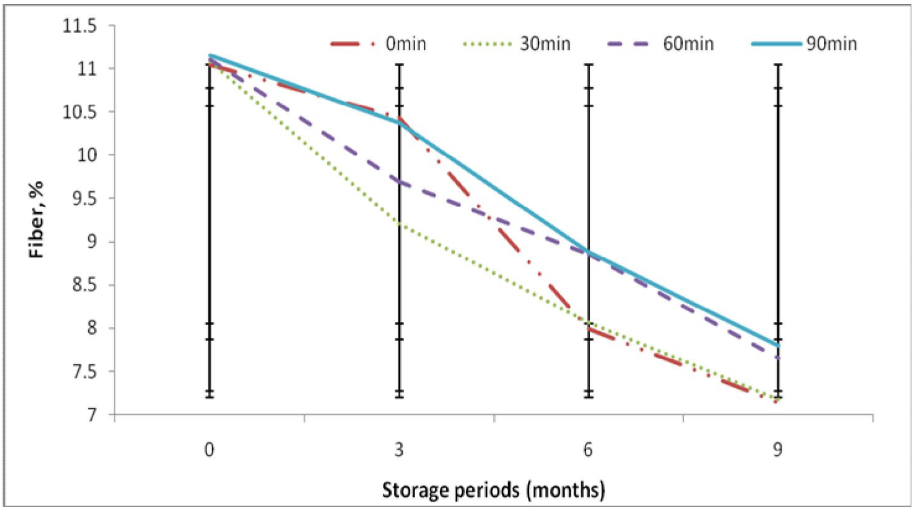


Fig. (4-12): Effect of UVC irradiation times on the fiber percentage of Faba bean during storage.

The illustrated results in Fig. (4-12) show the changing percentage of fibers in faba bean for treatments 0, 30, 60 and 90min. With time storage period, it could be indicated that the fiber percentage has an inverse relationship with storage period and Positive relationship with irradiation times which mean that it was decreased by increased storage period and decreasing UVC irradiation times. The decrease ranged from 0 to 9 months were (11.05-7.14%) and (11.08-7.18 %) can be achieved for (0 and 30 min.), while (11.11-7.65%) and (11.15-7.80%) for (60 and 90min.), respectively. While SD for treatments were 1.89, 1.68, 1.45 and 1.5 for (0, 30 ,60 and 90min), respectively

The average Fiber content of twelve faba bean cultivars was 6.1% it reported by **Al-nouri and siddiqi (1982)**.

4.3.5. Effect of laser exposure and UVC irradiation time on ash content of faba bean during storage periods:

Fig. (4-13 and 14) introduced the effect of laser exposure and UVC irradiation time on the ash content of faba bean during storage periods.

Fig. (4-13) indicated that the ash content increased by the increased storage period. The highest values (9months) were (3.95, 3.62%) can be achieved (45, 30 min.) and (3.62, 3.84%) for (15, 0), min. respectively. While SD for treatments were 1.08, 0.82, 0.54 and 0.42 for (0,15,30 and 45min), respectively.

From Fig. (4-14), it could be indicated that the ash content increased by increased storage period and decreasing irradiation times. The highest values (9months) were (3.84, 3.77, 3.71 and 3.68%) can be achieved (0, 30, 60) and 90min., respectively. While SD for treatments were 1.08, 0.99, 0.62 and 0.47 for (0,30,60 and 90min), respectively

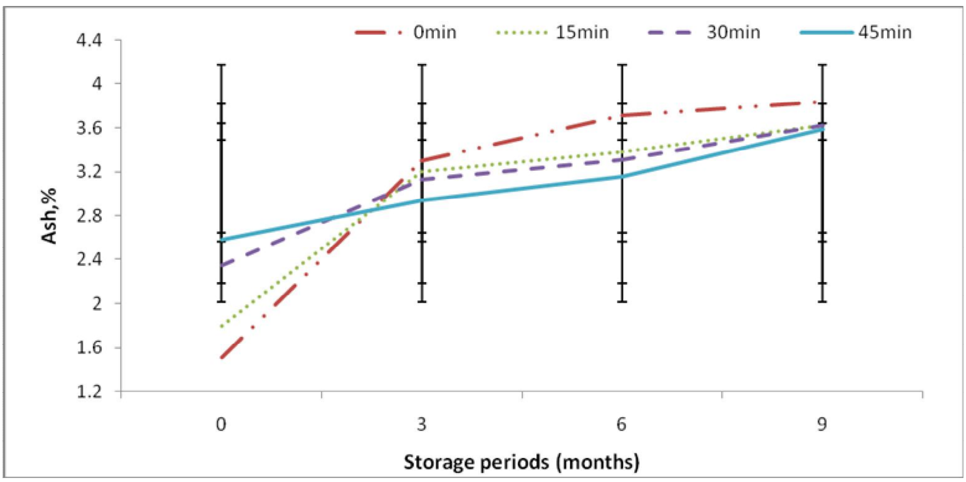


Fig. (4-13): Effect of laser exposure time on Ash percentage of Faba bean during storage time.

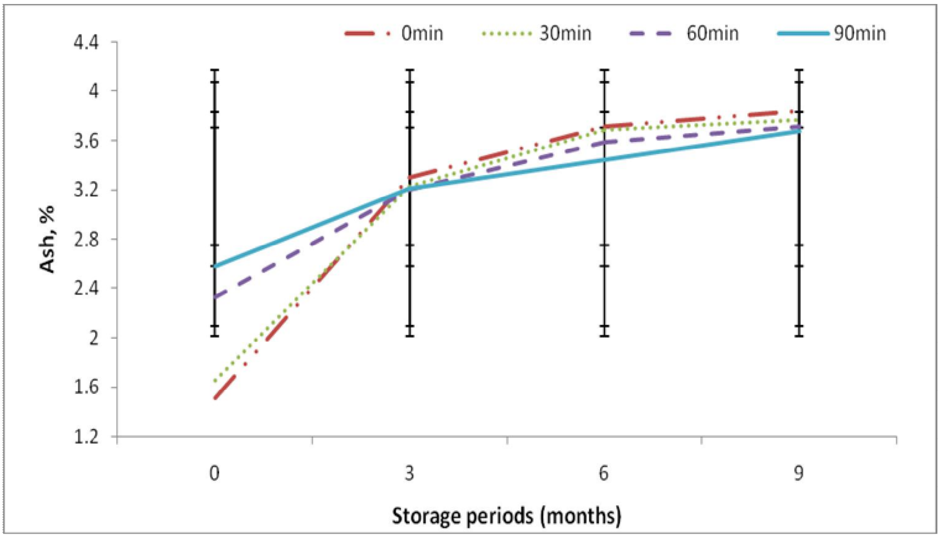


Fig.(4-14): Effect of UVC irradiation times on the ash percentage of Faba bean during storage.

Similar results were obtained by **Stefanello et al. (2015)** who stated that during the storage period, the metabolic activity of seeds and associated microorganisms consumes organic matter. So, increasing the intake of organic material will raise the ashes. While **Al-Nouri and Siddiqi (1982)** found that the average Ash for 12 faba bean cultivars was 3.2 %. The results agreed with those found by **Abeer et al. (2013),** which ranged from 3-3.35%.

4.3.6. Effect of laser exposure and UVC irradiation time on carbohydrate content of faba bean during storage periods:

Fig. (4-15 and 16) illustrated the effect of laser exposure and UVC irradiation time on the carbohydrate content of faba bean during storage periods.

Fig. (4-15) indicated that the carbohydrate percentage increased by increasing the storage time. The high carbohydrate after 9 months were (60.07 and 55.60%) can be achieved for (0 and 15min.) and (54.18 and 53.4%) for (30 and 15min.), respectively. While SD for treatments were 7.62, 4.33, 4.35 and 4.33 for (0,15,30 and 45min), respectively.

The results illustrated in Fig. (4-16) show the carbohydrate percentage, which increased by increasing the storage time and decreasing irradiation times. The increase range from 0 to 9 months was (42.1 - 60.07%) and (47.36 - 58.09%) can be achieved for (0 and 30 min.), while (45.67 - 56.14%) and (45.1 - 55.43%) for (60 and 90min.), respectively. While SD for treatments were 7.62, 4.45, 4.38 and 4.42 for (0,30,60 and 90min), respectively.

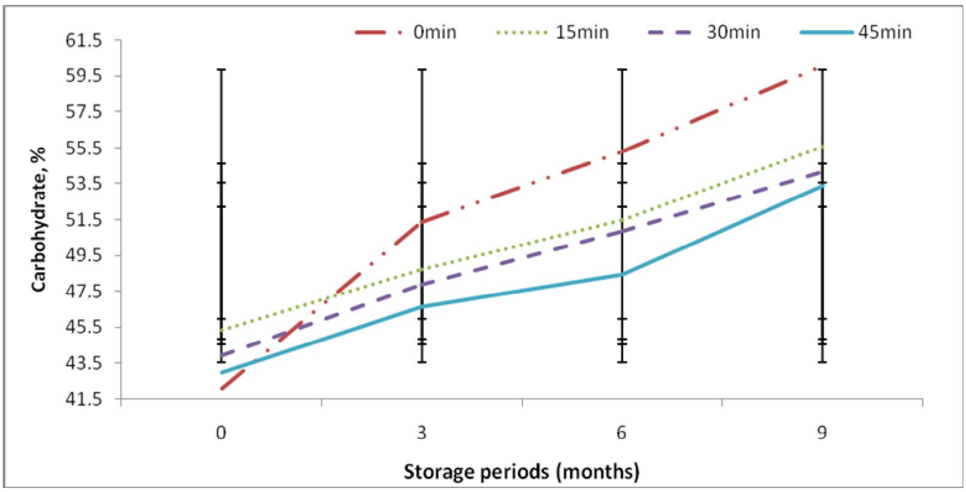


Fig. (4-15): Effect of laser exposure time on Carbohydrate percentage of Faba bean during storage time.

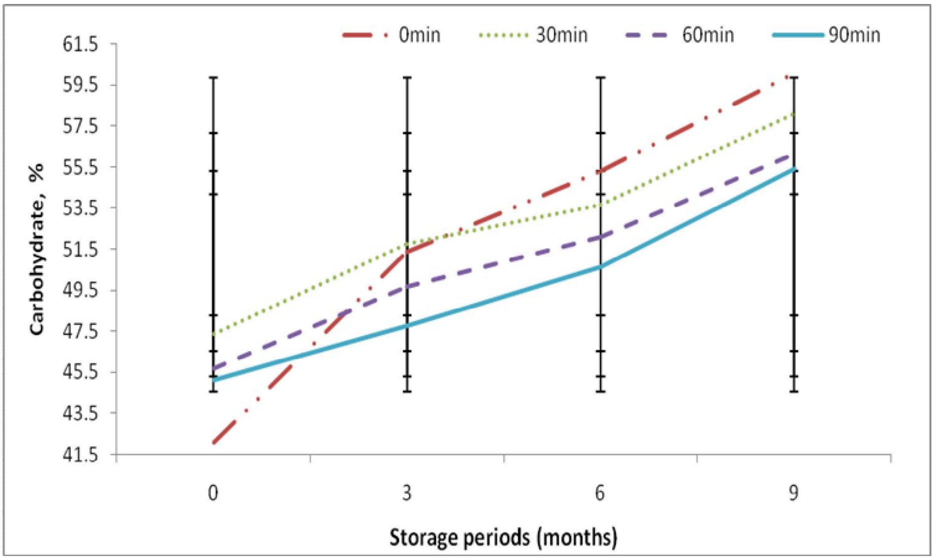


Fig. (4-16): Effect of UVC irradiation on the carbohydrate percentage of Faba bean during storage.

Stefanello et al. (2015) stated that the increase in the percentage of carbohydrates is related to the decrease between the protein and lipid fractions during storage. The carbohydrate content of faba beans ranged from 55-63% was reported by **Boghdady et al. (2017)**. **Abeer et al. (2013)** obtained 58 to 62.25.8% for carbohydrates of faba beans.

Figs. (4-5,6,7,8,9,1011,12,13,14,15 and 16) indicated that the effect of irradiation treatment with storage time on chemical properties of faba bean. Results show that protein, moisture content, fat, and fiber increased. While, ash and carbohydrate were decreased with increasing storage time. That may be occurring because of the chemical characteristics of degradation and/or of a request of its constituents during storage.

4.4. Biological properties of faba bean:

4.4.1. Effect of laser exposure and UVC irradiation time on total count of faba bean during storage periods:

Table (4-5) indicated that the total count cfu/g increased by increasing the storage period. The highest total count cfu/g after 9 month were ($4.5*10^6$and 880cfu/g) can be achieved for (0 and 15min.), and (640and 100cfu/g) for (30 and 45min.), respectively.

Table (4-6) indicated that the total count cfu/g increased by increasing the storage period. The highest total count cfu/g after 9 months were ($4.5*10^6$and $3.5*10^5$cfu/g) can be achieved for (0 and 30 min.), and (35000and 1800cfu/g) for (60 and 90min.), respectively.

Table (4-5) Effect of laser exposure time on total count of faba bean

Storage period (Months)	laser exposure time (min.)			
	0	15	30	45
0	<0.4	<0.1	<0.1	<0.1
3	100	30	14	<0.4
6	290000	320	120	30
9	4500000	880	640	100

Table (4-6) Effect of UVC irradiation time on Total count of faba bean

Storage period (Months)	UVC irradiation time (min.)			
	0	30	60	90
0	<0.4	<0.1	<0.1	<0.1
3	100	70	65	55
6	290000	550	450	350
9	4500000	350000	35000	1800

The result corresponding to **Alam et al, (2009)** who reported that irradiation has significantly affected on the bacterial count. And **Nandakumar et al, (2003)** found that TVC decreased with increasing duration of laser irradiation.

4.5. Color properties of faba bean:

4.5.1. Effect of laser exposure and UVC irradiation time on the color properties of faba bean during storage periods:

The average of the Cielab scale parameters L, a*,b* of faba bean seeds is indicated in Figs. (4- 17,18,19,20,21and 22) by using laser exposure and UVC irradiation time, during storage periods of 0,3,6 and 9 months.

It is clear from Fig. (4-17,18 and 19) that L and b* parameter decreases and a* increasing by increasing storage time. The initial L, a*, b* at 0 months were 47, 7 and 36, they were (22,12,22), (26,18,27), (27,14,28) and (37,14,29) after 9months for 0,15, 30 and 45min. for laser exposure time, respectively. When SD values for L, a* and b* for treatments were (10.55, 9.68, 8.77, 4.79), (6.22, 5.07, 4.65,3.16), and (6.08,4.03, 3.5,3.11) for (0,15,30 and 45min), respectively.

Fig. (4-20,21 and 22) showed that L and b* parameter decreases and a* increases by increasing the storage time. The initial L, a*, b* at 0 months were 47, 7 and 36 and they were (22,12,22), (23,20,22), (24,19,23) and (25,19,24) after 9months for 0,30, 60 and 90min. for UVC irradiation time, respectively. When SD values for L,a* and b* for treatments were (10.55, 10.63,10.42,10.05), (6.22, 5.94,5.5,5.29), and (6.08, 6.08, 5.56,5.32) for (0,30,60 and 90min), respectively.

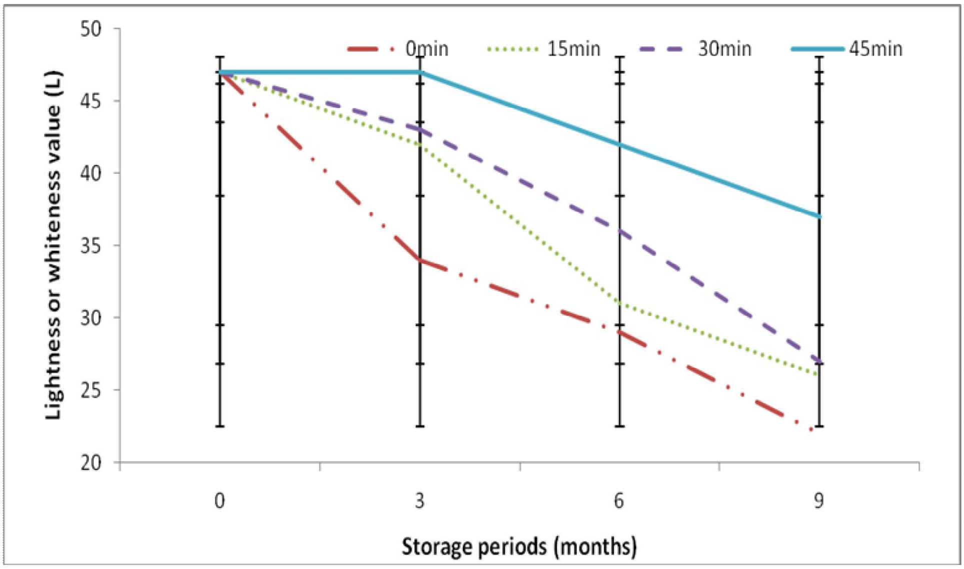


Fig (4-17): Effect of laser exposure time on Lightness or whiteness value (L) of Faba bean during storage time

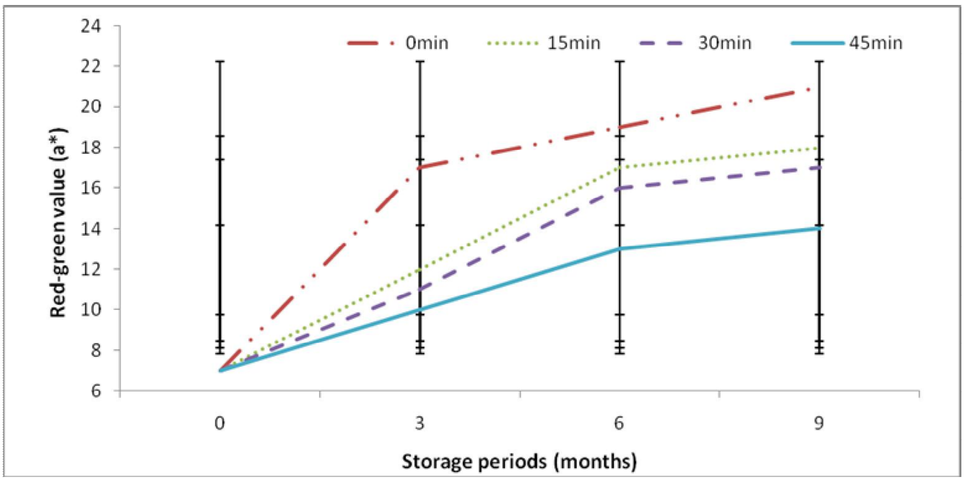


Fig 4-18: Effect of laser exposure time on Red-green value (a*) of Faba bean during storage time

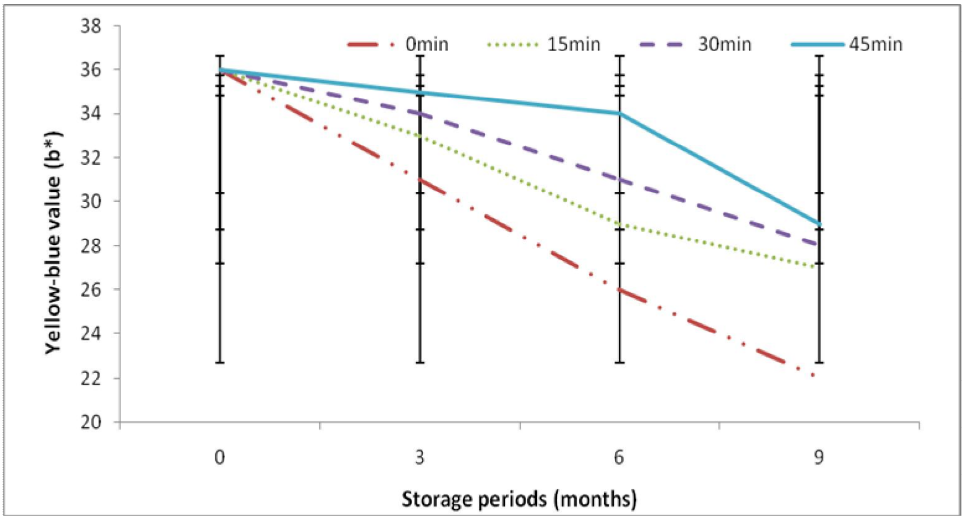


Fig (4-19): Effect of laser exposure time on Yellow-blue value (b*) of Faba bean during storage time

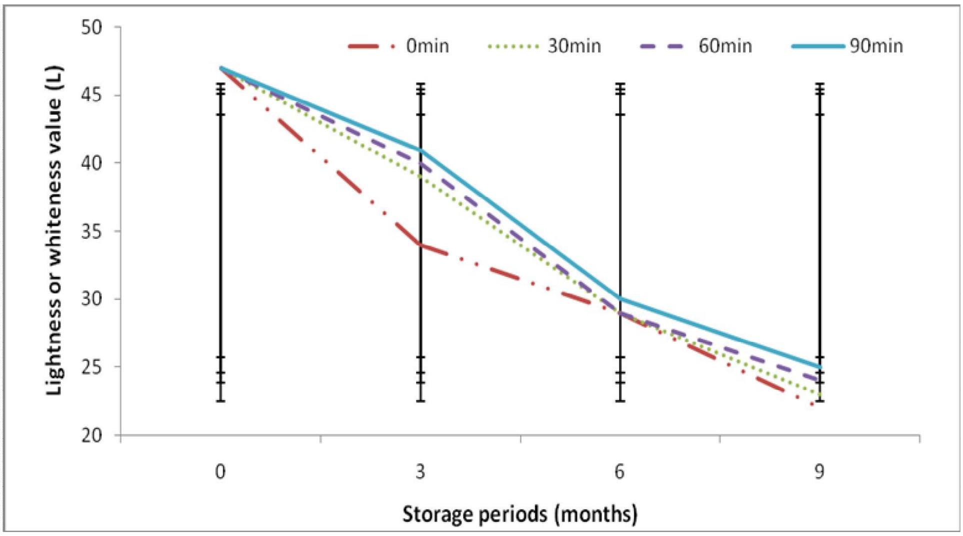


Fig (4-20): Effect of UVC irradiation on Lightness or whiteness value (L) of Faba bean during storage.

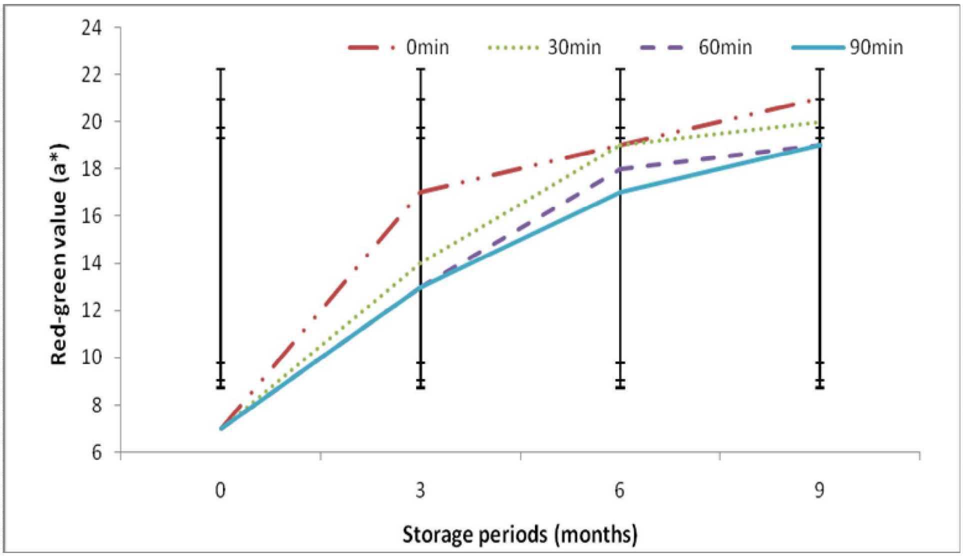


Fig (4-21): Effect of UVC irradiation on Red-green value (a*) of Faba bean during storage.

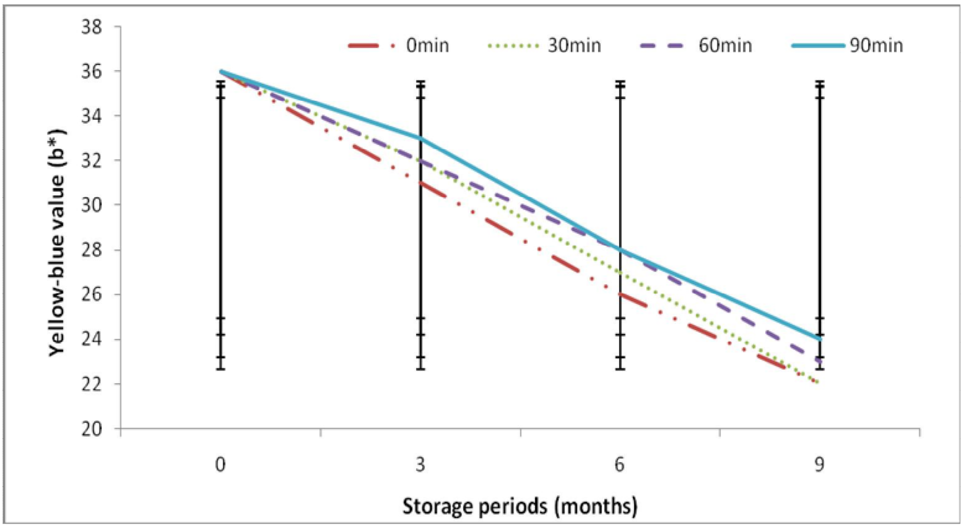


Fig (4-22): Effect of UVC irradiation on Yellow-blue value (b*) of Faba bean during storage.

4.6. Statistic analysis for Laser and UVC treatment:

4.6.1. Effect of laser exposure and UVC irradiation time on physical properties of faba bean during storage periods :

4.6.1.1. Effect of laser exposure and UVC irradiation time on principal dimensions of faba bean:

Table (4-7): ANOVA (Analysis of Variance) for the effect of laser exposure time on the length of faba bean seeds

ANOVA

Length

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.345	3	.782	7.437	.000
Within Groups	6.306	60	.105		
Total	8.651	63			

The correlation between laser treatment and length of faba bean seeds is worth mentioning because calculated F is significant at 0.05 Table (4-7).

The most remarkable result to emerge from the data in the Table (4-8) is that laser treatment at any level of exposure time (15, 30 and 45min.) has a significant effect in comparing with control (0min.).There were no significant differences between 30min. and 45min. with regard to length property, therefore using 30min. was feasible over 45min.

Table (4-8): LSD (Least Significant Difference) analysis for the effect of laser exposure time on length of faba bean seeds

Multiple Comparisons

Dependent Variable: Length
LSD

(I) Laser treatment	(J) Laser treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15min.	30min	-.05687-	.11462	.622	-.2862-	.1724
	45min	-.11312-	.11462	.328	-.3424-	.1162
	0min	.37563*	.11462	.002	.1463	.6049
30min	15min	.05687	.11462	.622	-.1724-	.2862
	45min	-.05625-	.11462	.625	-.2855-	.1730
	0min	.43250*	.11462	.000	.2032	.6618
45min	15min	.11312	.11462	.328	-.1162-	.3424
	30min	.05625	.11462	.625	-.1730-	.2855
	0min	.48875*	.11462	.000	.2595	.7180
0min	15min	-.37563-*	.11462	.002	-.6049-	-.1463-
	30min	-.43250-*	.11462	.000	-.6618-	-.2032-
	45min	-.48875-*	.11462	.000	-.7180-	-.2595-

*. The mean difference is significant at the 0.05 level.

Table (4-9) indicated that there were significant differences between laser treatment and width of faba bean seeds at 0.05.

Table (4-9): Analysis of Variance for the effect of laser exposure time on width of faba bean seeds

ANOVA

width

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.970	3	.323	7.401	.000
Within Groups	2.621	60	.044		
Total	3.591	63			

Table (4-10): Least Significant Difference analysis for the effect of laser exposure time on width of faba bean seeds

Multiple Comparisons

Dependent Variable: width

LSD

(I) Laser treatment	(J) Laser treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15min	30min	-.07938-	.07389	.287	-.2272-	.0684
	45min	-.12875-	.07389	.087	-.2766-	.0191
	0min	.19437*	.07389	.011	.0466	.3422
30min	15min	.07938	.07389	.287	-.0684-	.2272
	45min	-.04937-	.07389	.507	-.1972-	.0984
	0min	.27375*	.07389	.000	.1259	.4216
45min	15min	.12875	.07389	.087	-.0191-	.2766
	30min	.04937	.07389	.507	-.0984-	.1972
	0min	.32312*	.07389	.000	.1753	.4709
0min	15min	-.19437-*	.07389	.011	-.3422-	-.0466-
	30min	-.27375-*	.07389	.000	-.4216-	-.1259-
	45min	-.32312-*	.07389	.000	-.4709-	-.1753-

*. The mean difference is significant at the 0.05 level.

Table (4-10) shows that there was a significant between laser treatment at any level of time exposure (15, 30 and 45min.) and control treatment (0min.).The single most striking observation to emerge from the data comparison was no significant differences between 30 and 45min. in terms of width of faba bean.

Table (4-11): ANOVA for the effect of laser exposure time on thickness of faba bean seeds

ANOVA

Thickness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.275	3	.092	5.976	.001
Within Groups	.919	60	.015		
Total	1.194	63			

These test summarized that there a significant difference was observed at the 0.05 level as shown in Table (4-11).

Table (4-12): LSD analysis for the effect of laser exposure time on the thickness of faba bean seeds

Multiple Comparisons

Dependent Variable: Thickness

LSD

(I) Laser treatment	(J) Laser treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15min	30min	-.02375-	.04376	.589	-.1113-	.0638
	45min	-.10500-*	.04376	.020	-.1925-	-.0175-
	0min	.07875	.04376	.077	-.0088-	.1663
30min	15min	.02375	.04376	.589	-.0638-	.1113
	45min	-.08125-	.04376	.068	-.1688-	.0063
	0min	.10250*	.04376	.022	.0150	.1900
45min	15min	.10500*	.04376	.020	.0175	.1925
	30min	.08125	.04376	.068	-.0063-	.1688
	0min	.18375*	.04376	.000	.0962	.2713
0min	15min	-.07875-	.04376	.077	-.1663-	.0088
	30min	-.10250-*	.04376	.022	-.1900-	-.0150-
	45min	-.18375-*	.04376	.000	-.2713-	-.0962-

*. The mean difference is significant at the 0.05 level.

As highlighted in the Table (4-12), the value of the mean difference is significant only between laser treatment at any level of time exposure (30 and 45min.) and control treatment (0min.).This finding points to the usefulness of laser treatment at the level of time exposure (45min.) as a mean difference is more significant compared with 30min.

Table (4-13): Analysis of Variance for the effect of UVC irradiation time on Principal Dimensions of faba bean seeds

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Length	Between Groups	1.150	3	.383	2.019	.121
	Within Groups	11.392	60	.190		
	Total	12.542	63			
width	Between Groups	.248	3	.083	1.862	.146
	Within Groups	2.666	60	.044		
	Total	2.914	63			
Thickness	Between Groups	.049	3	.016	1.182	.324
	Within Groups	.829	60	.014		
	Total	.878	63			

Table (4-13) shows that none of these differences were statistically significant at the 0.05 level.

4.6.1.2. Effect of laser exposure and UVC irradiation time on the mass, volume and density of faba bean:

As shown in Table (4-14), the value of the correlation between laser treatment and mass of faba beans seeds is interesting because calculated F is significant at 0.05.

Table (4-14): Analysis of variance for the effect of laser exposure time on the mass of faba bean seeds

ANOVA

Mass

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	111.053	3	37.018	19.970	.000
Within Groups	111.221	60	1.854		
Total	222.275	63			

As we can be seen in Table (4-15), the value of the analysis did not show any significant differences between 15, 30 and 45min. in terms of mass of faba bean.

Table (4-15): LSD analysis for the effect of laser exposure time on the mass of faba bean seeds

Multiple Comparisons

Dependent Variable: Mass

LSD

(I) Laser treatment	(J) Laser treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15min	30min	-.11812-	.48136	.807	-1.0810-	.8447
	45min	-1.24062-*	.48136	.012	-2.2035-	-.2778-
	0min	2.37625*	.48136	.000	1.4134	3.3391
30min	15min	.11812	.48136	.807	-.8447-	1.0810
	45min	-1.12250-*	.48136	.023	-2.0854-	-.1596-
	0min	2.49438*	.48136	.000	1.5315	3.4572
45min	15min	1.24062*	.48136	.012	.2778	2.2035
	30min	1.12250*	.48136	.023	.1596	2.0854
	0min	3.61688*	.48136	.000	2.6540	4.5797
0min	15min	-2.37625-*	.48136	.000	-3.3391-	-1.4134-
	30min	-2.49438-*	.48136	.000	-3.4572-	-1.5315-
	45min	-3.61688-*	.48136	.000	-4.5797-	-2.6540-

*. The mean difference is significant at the 0.05 level.

Table (4-16): Analysis of variance for the effect of laser exposure time on the true Volume of faba bean seeds

ANOVA

True Volume

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1248.781	3	416.260	9.664	.000
Within Groups	2584.267	60	43.071		
Total	3833.048	63			

The most remarkable result to emerge from the data in Table (4- 16) is that there a significant difference at the 0.05 level.

As observed from Table (4-17) that the mean difference is significant between laser treatment at any level of exposure time (15, 30 and 45min.) and control treatment (0min.).There were no significant differences between 30min. and 45min. in terms of true volume property, therefore using 30min. was Feasible over 45min.

Table (4-17): LSD (Least Significant Difference) analysis for the effect of laser exposure time on the true volume of faba bean seeds

Multiple Comparisons

Dependent Variable: True Volume

LSD

(I) Laser treatment	(J) Laser treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15min	30min	-.47562-	2.32032	.838	-5.1170-	4.1657
	45min	-3.83125-	2.32032	.104	-8.4726-	.8101
	0min	8.17875*	2.32032	.001	3.5374	12.8201
30min	15min	.47562	2.32032	.838	-4.1657-	5.1170
	45min	-3.35562-	2.32032	.153	-7.9970-	1.2857
	0min	8.65438*	2.32032	.000	4.0130	13.2957
45min	15min	3.83125	2.32032	.104	-.8101-	8.4726
	30min	3.35562	2.32032	.153	-1.2857-	7.9970
	0min	12.01000*	2.32032	.000	7.3687	16.6513
0min	15min	-8.17875-*	2.32032	.001	-12.8201-	-3.5374-
	30min	-8.65438-*	2.32032	.000	-13.2957-	-4.0130-
	45min	-12.01000-*	2.32032	.000	-16.6513-	-7.3687-

*. The mean difference is significant at the 0.05 level.

Table (4-18): ANOVA for the effect of laser exposure time on the bulk volume of faba bean seeds

ANOVA

Bulk Volume

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	178.058	3	59.353	11.697	.000
Within Groups	304.454	60	5.074		
Total	482.512	63			

These ANOVA test outlined from the Table (4-18) that there a significant difference was detected at the 0.05 level.

Table (4-19): LSD (Least Significant Difference) analysis for the effect of laser exposure time on the bulk volume of faba bean seeds

Multiple Comparisons

Dependent Variable: Bulk Volume

LSD

(I) Laser treatment	(J) Laser treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15min	30min	-2.16562-*	.79642	.009	-3.7587-	-.5726-
	45min	-3.25250-*	.79642	.000	-4.8456-	-1.6594-
	0min	.93750	.79642	.244	-.6556-	2.5306
30min	15min	2.16562*	.79642	.009	.5726	3.7587
	45min	-1.08688-	.79642	.177	-2.6799-	.5062
	0min	3.10312*	.79642	.000	1.5101	4.6962
45min	15min	3.25250*	.79642	.000	1.6594	4.8456
	30min	1.08688	.79642	.177	-.5062-	2.6799
	0min	4.19000*	.79642	.000	2.5969	5.7831
0min	15min	-.93750-	.79642	.244	-2.5306-	.6556
	30min	-3.10312-*	.79642	.000	-4.6962-	-1.5101-
	45min	-4.19000-*	.79642	.000	-5.7831-	-2.5969-

*. The mean difference is significant at the 0.05 level.

Table (4-19) demonstrates that the mean difference is significant only between laser treatment at any level of time exposure (30 and 45min.) and control treatment (0min.). The single most conspicuous observation to emerge from the data comparison was no significant differences between 30min. and 45min. in terms of Bulk Volume of faba bean.

Table (4-20): ANOVA (Analysis of Variance) for the effect of laser exposure time on true density of faba bean seeds

ANOVA

True density

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.005	3	.002	4.463	.007
Within Groups	.024	60	.000		
Total	.030	63			

Table (4-20) shows that there a significant difference was highlighted at the 0.05 level.

The multiple Comparison test from the Table (4-21) summarized that there was a significant difference between laser treatments at the level of exposure time (15, 30 and 45min.) and control treatment (0min.). However, laser treatment at the level of exposure time (45min.) is more significant compared with other treatment.

Table (4-21): LSD (Least Significant Difference) analysis for the effect of laser exposure time on true density of faba bean seeds

Multiple Comparisons

Dependent Variable: True density

LSD

(I) Laser treatment	(J) Laser treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15min	30min	.00000	.00710	1.000	-.0142-	.0142
	45min	.00750	.00710	.295	-.0067-	.0217
	0min	-.01750-*	.00710	.017	-.0317-	-.0033-
30min	15min	.00000	.00710	1.000	-.0142-	.0142
	45min	.00750	.00710	.295	-.0067-	.0217
	0min	-.01750-*	.00710	.017	-.0317-	-.0033-
45min	15min	-.00750-	.00710	.295	-.0217-	.0067
	30min	-.00750-	.00710	.295	-.0217-	.0067
	0min	-.02500-*	.00710	.001	-.0392-	-.0108-
0min	15min	.01750*	.00710	.017	.0033	.0317
	30min	.01750*	.00710	.017	.0033	.0317
	45min	.02500*	.00710	.001	.0108	.0392

*. The mean difference is significant at the 0.05 level.

Table (4-22): ANOVA (Analysis of Variance) for the effect of laser exposure time on bulk density of faba bean seeds

ANOVA

Bulk density

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.011	3	.004	10.394	.000
Within Groups	.021	60	.000		
Total	.032	63			

Table (4-22) highlights that the correlation between laser treatment and bulk density of faba bean seeds is worth noting because calculated F is significant at 0.05.

We note from Table (4-23) that the analysis shows that there was a significant between laser treatments at any level of exposure time (15, 30 and 45min.) and control treatment (0min.). And the Table highlighted that laser treatment at the level of exposure time (15 min.) is more significant compared with other treatments (30 and 45 min.).

Table (4-23): LSD (Least Significant Difference) analysis for the effect of laser exposure time on bulk density of faba bean seeds

Multiple Comparisons

Dependent Variable: Bulk density

LSD

(I) Laser treatment	(J) Laser treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15min	30min	.031188*	.006614	.000	.01796	.04442
	45min	.032062*	.006614	.000	.01883	.04529
	0min	.016625*	.006614	.015	.00339	.02986
30min	15min	-.031188-*	.006614	.000	-.04442-	-.01796-
	45min	.000875	.006614	.895	-.01236-	.01411
	0min	-.014563-*	.006614	.032	-.02779-	-.00133-
45min	15min	-.032062-*	.006614	.000	-.04529-	-.01883-
	30min	-.000875-	.006614	.895	-.01411-	.01236
	0min	-.015437-*	.006614	.023	-.02867-	-.00221-
0min	15min	-.016625-*	.006614	.015	-.02986-	-.00339-
	30min	.014563*	.006614	.032	.00133	.02779
	45min	.015437*	.006614	.023	.00221	.02867

*. The mean difference is significant at the 0.05 level.

Table (4-24): ANOVA for the effect of UVC irradiation time on mass of faba bean seeds.

ANOVA

Mass

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	51.395	3	17.132	5.734	.002
Within Groups	179.274	60	2.988		
Total	230.669	63			

The correlation between UV treatment and mass of faba beans seeds is worth mentioning because calculated F is significant at 0.05as show in the Table (4-24).

Table (4-25): Least Significant Difference (LSD) analysis for the effect of UVC irradiation time on mass of faba bean seeds

Multiple Comparisons

Dependent Variable: Mass

LSD

(I) UV treatment	(J) UV treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
30min	60min	-1.18062-	.61114	.058	-2.4031-	.0418
	90min	-1.30313-*	.61114	.037	-2.5256-	-.0807-
	0min	.87563	.61114	.157	-.3468-	2.0981
60min	30min	1.18062	.61114	.058	-.0418-	2.4031
	90min	-.12250-	.61114	.842	-1.3450-	1.1000
	0min	2.05625*	.61114	.001	.8338	3.2787
90min	30min	1.30313*	.61114	.037	.0807	2.5256
	60min	.12250	.61114	.842	-1.1000-	1.3450
	0min	2.17875*	.61114	.001	.9563	3.4012
0min	30min	-.87563-	.61114	.157	-2.0981-	.3468
	60min	-2.05625-*	.61114	.001	-3.2787-	-.8338-
	90min	-2.17875-*	.61114	.001	-3.4012-	-.9563-

*. The mean difference is significant at the 0.05 level.

Table (4-25) demonstrates that the mean difference is significant only between UV treatment at any level of exposure time (60 and 90min.) and control treatment (0min.).

Table (4-26): ANOVA (Analysis of Variance) for the effect of UVC irradiation time on the true volume, true density and bulk density of faba bean seeds

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
True Volume	Between Groups	328.166	3	109.389	1.408	.249
	Within Groups	4660.628	60	77.677		
	Total	4988.795	63			
True density	Between Groups	.003	3	.001	1.626	.193
	Within Groups	.041	60	.001		
	Total	.044	63			
Bulk density	Between Groups	.005	3	.002	1.852	.147
	Within Groups	.050	60	.001		
	Total	.054	63			

Table (4-26) illustrates that none of these differences were statistically significant at the 0.05 level.

Table (4-27): Analysis of Variance (ANOVA) for the effect of UVC irradiation time on the bulk volume of faba bean seeds

ANOVA

Bulk Volume

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	101.373	3	33.791	4.495	.007
Within Groups	451.015	60	7.517		
Total	552.388	63			

As observe from the Table (4-27) that the most remarkable result to emerge from the data is that there a significant difference at the 0.05 level.

Table (4-28): Least Significant Difference analysis for the effect of UVC irradiation time on bulk volume of faba bean seeds

Multiple Comparisons

Dependent Variable: Bulk Volume
LSD

(I) UV treatment	(J) UV treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
30min	60min	-1.79687-	.96934	.069	-3.7358-	.1421
	90min	-2.72750-*	.96934	.007	-4.6665-	-.7885-
	0min	.31437	.96934	.747	-1.6246-	2.2533
60min	30min	1.79687	.96934	.069	-.1421-	3.7358
	90min	-.93063-	.96934	.341	-2.8696-	1.0083
	0min	2.11125*	.96934	.033	.1723	4.0502
90min	30min	2.72750*	.96934	.007	.7885	4.6665
	60min	.93063	.96934	.341	-1.0083-	2.8696
	0min	3.04187*	.96934	.003	1.1029	4.9808
0min	30min	-.31437-	.96934	.747	-2.2533-	1.6246
	60min	-2.11125-*	.96934	.033	-4.0502-	-.1723-
	90min	-3.04187-*	.96934	.003	-4.9808-	-1.1029-

*. The mean difference is significant at the 0.05 level.

Table (4-28) shown that the mean difference is significant only between UV treatment at any level of exposure time (60 and 90min.) and control treatment (0min.).

4.6.2. Effect of laser exposure and UVC irradiation time on the mechanical properties of faba bean during storage periods :

4.6.2.1. Effect of laser exposure and UVC irradiation time on the shear force of faba bean

The Analysis of variance (ANOVA) in the Table (4-29) shows that there a significant difference was observed at the 0.05 level.

Table (4-29): ANOVA (Analysis of Variance) for the effect of laser exposure time on the shear force of faba bean seeds

ANOVA

Shear force

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	75979.256	3	25326.419	3.092	.034
Within Groups	491407.754	60	8190.129		
Total	567387.009	63			

Table (4-30) highlights that the result of the mean difference is significant only at laser treatment at level of time exposure (30 and 45min.).

Table (4-30): LSD (Least Significant Difference) analysis for the effect of laser exposure time on shear force of faba bean seeds

Multiple Comparisons

Dependent Variable: Shear force

LSD

(I) Laser treatment	(J) Laser treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15min	30min	12.78125	31.99635	.691	-51.2210-	76.7835
	45min	33.55000	31.99635	.299	-30.4522-	97.5522
	0min	-59.16875-	31.99635	.069	-123.1710-	4.8335
30min	15min	-12.78125-	31.99635	.691	-76.7835-	51.2210
	45min	20.76875	31.99635	.519	-43.2335-	84.7710
	0min	-71.95000-*	31.99635	.028	-135.9522-	-7.9478-
45min	15min	-33.55000-	31.99635	.299	-97.5522-	30.4522
	30min	-20.76875-	31.99635	.519	-84.7710-	43.2335
	0min	-92.71875-*	31.99635	.005	-156.7210-	-28.7165-
0min	15min	59.16875	31.99635	.069	-4.8335-	123.1710
	30min	71.95000*	31.99635	.028	7.9478	135.9522
	45min	92.71875*	31.99635	.005	28.7165	156.7210

*. The mean difference is significant at the 0.05 level.

Table (4-31): ANOVA (Analysis of Variance) for the effect of laser exposure time on Penetration force of faba bean seeds

ANOVA

Penetration force

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	110282.593	3	36760.864	5.194	.003
Within Groups	424673.265	60	7077.888		
Total	534955.858	63			

As observe from Table (4-31) that the analysis reveals significant differences between laser treatment and Penetration force of faba beans seeds at the 0.05 level.

Table (4-32): LSD (Least Significant Difference) analysis for the effect of laser exposure time on Penetration force of faba bean seeds

Multiple Comparisons

Dependent Variable: Penetration force
LSD

(I) Laser treatment	(J) Laser treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15min	30min	7.36250	29.74451	.805	-52.1354-	66.8604
	45min	20.88750	29.74451	.485	-38.6104-	80.3854
	0min	-84.87500-*	29.74451	.006	-144.3729-	-25.3771-
30min	15min	-7.36250-	29.74451	.805	-66.8604-	52.1354
	45min	13.52500	29.74451	.651	-45.9729-	73.0229
	0min	-92.23750-*	29.74451	.003	-151.7354-	-32.7396-
45min	15min	-20.88750-	29.74451	.485	-80.3854-	38.6104
	30min	-13.52500-	29.74451	.651	-73.0229-	45.9729
	0min	-105.76250-*	29.74451	.001	-165.2604-	-46.2646-
0min	15min	84.87500*	29.74451	.006	25.3771	144.3729
	30min	92.23750*	29.74451	.003	32.7396	151.7354
	45min	105.76250*	29.74451	.001	46.2646	165.2604

*. The mean difference is significant at the 0.05 level.

Table (4-32) illustrates that the Multiple Comparisons summarized that there was a significant difference between the laser treatment at any level of exposure time (15, 30 and 45min.) and control treatment (0min.). However, laser treatment at level of exposure time (45min.) is more significant compared with other treatments.

Table (4-33): ANOVA (Analysis of Variance) for the effect of UVC irradiation time on Shear and Penetration force of faba bean seeds

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Shear	Between Groups	16719.872	3	5573.291	.680	.568
	Within Groups	491741.679	60	8195.695		
	Total	508461.551	63			
Penetration	Between Groups	62135.371	3	20711.790	2.528	.066
	Within Groups	491609.139	60	8193.486		
	Total	553744.510	63			

Table (4-33) highlights that none of these differences were statistically significant at the 0.05 level.

4.6.3. Effect of laser exposure and UVC irradiation time on the chemical properties of faba bean during storage periods:

4.6.3.1.<u>Effect of laser exposure time on the fat percent of faba bean</u>

Table (4-34): ANOVA (Analysis of Variance) for the effect of laser exposure time on fat of faba bean seeds

ANOVA

Fat content

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.439	3	4.480	5.625	.002
Within Groups	47.786	60	.796		
Total	61.226	63			

The most striking result to emerge from the data in the Table (4-34) is that there a significant difference at the 0.05 level.

Table (4-35): LSD (Least Significant Difference) analysis for the effect of laser exposure time on fat of faba bean seeds

Multiple Comparisons

Dependent Variable: fat content

LSD

(I) Laser treatment	(J) Laser treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
15min	30min	-.09438-	.31552	.766	-.7255-	.5368
	45min	-.18625-	.31552	.557	-.8174-	.4449
	0min	.95375*	.31552	.004	.3226	1.5849
30min	15min	.09438	.31552	.766	-.5368-	.7255
	45min	-.09187-	.31552	.772	-.7230-	.5393
	0min	1.04813*	.31552	.002	.4170	1.6793
45min	15min	.18625	.31552	.557	-.4449-	.8174
	30min	.09187	.31552	.772	-.5393-	.7230
	0min	1.14000*	.31552	.001	.5089	1.7711
0min	15min	-.95375-*	.31552	.004	-1.5849-	-.3226-
	30min	-1.04813-*	.31552	.002	-1.6793-	-.4170-
	45min	-1.14000-*	.31552	.001	-1.7711-	-.5089-

*. The mean difference is significant at the 0.05 level.

The most remarkable result to emerge from the data in the Table (4-35) is that laser treatment at any level of exposure time (15, 30 and 45min.) has significant effect in comparing with control (0min.).

4.6.3.2.Effect of laser exposure time on protein, moisture content, fiber, Ash and carbohydrate percent of faba bean

It was note from Table (4-36) that none of these differences were statistically significant at the 0.05 level.

Table (4-36): ANOVA (Analysis of Variance) for the effect of laser exposure time on the protein, moisture content, fiber, ash and carbohydrate percentage of faba bean seeds

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
protein	Between Groups	29.816	3	9.939	1.379	.258
	Within Groups	432.539	60	7.209		
	Total	462.355	63			
moisture content	Between Groups	.923	3	.308	.627	.601
	Within Groups	29.463	60	.491		
	Total	30.386	63			
fiber	Between Groups	10.737	3	3.579	1.907	.138
	Within Groups	112.638	60	1.877		
	Total	123.375	63			
Ash	Between Groups	.100	3	.033	.072	.975
	Within Groups	27.645	60	.461		
	Total	27.744	63			
carbohydrate	Between Groups	160.743	3	53.581	2.339	.082
	Within Groups	1374.654	60	22.911		
	Total	1535.397	63			

4.6.3.3. Effect of UVC irradiation time on chemical properties of faba bean during storage periods:

It was observed in the Table (4-37) that none of these differences were statistically significant at the 0.05 level.

Table (4-37): Analysis of Variance (ANOVA) for the effect of UVC irradiation time on the chemical properties of faba bean seeds

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
protein	Between Groups	22.758	3	7.586	1.233	.306
	Within Groups	369.247	60	6.154		
	Total	392.005	63			
moisture content	Between Groups	.487	3	.162	.348	.791
	Within Groups	28.027	60	.467		
	Total	28.515	63			
fat	Between Groups	2.754	3	.918	.687	.564
	Within Groups	80.188	60	1.336		
	Total	82.942	63			
fiber	Between Groups	3.831	3	1.277	.594	.621
	Within Groups	129.027	60	2.150		
	Total	132.858	63			
Ash	Between Groups	1.572	3	.524	.903	.445
	Within Groups	34.806	60	.580		
	Total	36.378	63			
carbohydrate	Between Groups	86.436	3	28.812	1.235	.305
	Within Groups	1399.455	60	23.324		
	Total	1485.892	63			

5. SUMMARY AND CONCLUSION

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The experiments were started in the spring season (May, 2018) located in Giza governorate (Agricultural Engineering Research Institute) by setup and constructed the system and irradiation by Ultraviolet-C and irradiation by Laser in Laser application in Agricultural Engineering – National Institute of Laser Enhanced Science - Cairo university. After exposure by Laser and UV-C light, each sample was placed in a plastic bag and stored for nine months at room temperature. Four samples are taken from each treatment every three months and determined Physical, mechanical, chemical, microbial and color analysis changes to observe the changes that occur during the storage period.

The obtained results can be summarized as the following :

5.1. Physical properties of faba bean:

1- There was a difference in three principal dimensions (length, width and thickness) of faba bean seeds, where they decreased by increasing the storage period and decreasing laser exposure and UV-C irradiation time, where it were the lowest reduction in principal dimensions in the treatments of 45 min and 90 min for laser and UV-C treatment which recorded 15.74 – 15.48, 11.96-

11.65 and 5.62 – 5.48 mm for length, width and thickness, for laser and UV-C treatment respectively.

Meanwhile the highest reduction recorded for control treatment 14.72, 11.33 and 5.31 mm for length, width and thickness, respectively.

2- There was a difference in mass, bulk and true volume of faba bean seeds, where they decreased by increasing the storage period and decreasing laser exposure and UV-C irradiation time, where it were the lowest reduction in mass, bulk and true volume recorded for treatments of 45 min and 90 min for laser and UV-C treatment which recorded 85 - 82.68 g, 76.53 - 70.5 cm^3 and 149 -140cm^3 for mass, bulk and true volume, for laser and UV-C treatment respectively.

   Meanwhile the highest reduction recorded for control treatment 79.09g, 67.18 cm^3 and 126 cm^3 for mass, bulk and true volume, respectively.

3- The bulk and true density increase by increasing the storage period, and increasing laser exposure and UVC irradiation time, where it were the lowest increase in bulk and true density recorded for treatments of 45min and 90min for laser and UVC treatment which recorded 1.111 – 1.173 and 0.57 – 0.59cm^3 for bulk and true density, respectively.

Meanwhile the highest increase recorded for control treatment 1.177 and 0.63cm^3 for bulk and true density, respectively.

5.2. Mechanical properties of faba bean:

The shear and Penetration force was increased as the storage periods increase, and decreasing laser exposure and UVC irradiation time, where the lowest increase recorded for 45 and 90min treatment of 45min for laser and UVC treatment which recorded 503.9- 590.9 and 463.3- 510.4N for shear and Penetration force, respectively.

Meanwhile the highest increase recorded for control treatment 597.0 and 576.1N for shear and Penetration force, respectively.

5.3. Chemical properties:

1- Result showed that protein, moisture content, fat, and fiber were decreased by decreasing laser exposure and UVC irradiation time and increasing the storage period. Where the lowest reduction recorded for 45 and 90min treatment of 45min for laser and UVC treatment which recorded 23.22- 23.25, 9.20- 9.13, 2.00- 0.71and

8.58- 7.80% for protein, moisture content, fat, and fiber, respectively.

while the highest reduction recorded for control treatment 20.15, 8.70, 0.10 and 7.14% for protein, moisture content, fat, and fiber, respectively.

2- Meanwhile, ash and carbohydrate were increased by increasing storage period and by decreasing laser exposure and UVC irradiation time. The lowest increase recorded for 45 and 90min treatment of 45min for laser and UVC treatment which recorded 3.59 – 3.68 and 53.41- 55.43for ash and carbohydrate, respectively. While the highest increase recorded for control treatment 3.59 – 3.84 and 60.07 for ash and carbohydrate, respectively.

5.4. Biological properties:

The highest Total count cfu/g after 9 month were ($4.5*10^6$cfu/g) can be achieved for (0min), and 100 cfu/g for 45min and was 1800 cfu/g for 90min for laser and UVC treatment, respectively.

5.5. Color properties:

Result showed that L and b* parameter decreasing and a* increasing by increasing storage time. The initial L, a*, b* at 0 months were 47, 7 and 36 and they were (37, 14, 29) and (25, 19, 24) after 9months for 45min and 90min for laser and UVC treatment, respectively.

From pervious results it was concluded that:-

- Laboratory chemical experiments are currently used in Egypt to check the quality of the faba bean seed, and from the results of the thesis it was recommend using of laser or UVC irradiation technology to improve the quality of the bean seed.
- It was recommended to use the new technology such as laser light and UVC as treatments for safe storage for seeds.
- Design and fabricated irradiation device in order to worle during transportation and handling the grains.
- Using laser or UV technique to irradiation the seeds before its storage.
- The technique that could be preferred to use in Egypt for the conservation of the quality of faba bean it is laser treatment at level of exposure time (45 min), followed by treatment UVC irradiation time at (90 min) .
- It was recommended using of laser or UVC irradiation technology to improve the quality of the cereal crops.

6. REFERENCES

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7. ANNEX

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Research Article
Ultraviolet Effect on Faba Bean Seed Quality During Storage

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Abstract

Background and Objective: Legumes play an important role in human nutrition since they are rich sources of protein, calories, minerals and vitamins and therefore can be good supplements. In order to extant shelf life and reduce loss of faba bean seeds during storage of 9 months, the different doses of ultraviolet irradiation were used. The main purpose of the present study was to observe the effect of Ultraviolet irradiation times on faba bean seed quality. **Materials and Methods:** The seeds of faba bean were investigated in the experiment. Three irradiation times of UVC investigated were of 30, 60 and 90 min of exposure times were used, also and 0 min for treatment without irradiation. During storage period, chemical, physical and mechanical analysis changes were determined. **Results:** (a) The main dimensions, mass and bulk volume and true volume were decreased by increasing the storage period and decreasing ultraviolet irradiation time. Meanwhile, the bulk and true density were increased by increasing storage period and decreasing ultraviolet irradiation time and (b) The protein, moisture content, fat and fiber were increased. While, the ash and carbohydrate were decreased with increasing storage period. **Conclusion:** This technique extend the shelf-life of the faba bean grains, reduce the loss of faba bean grains during storage period of nine months and use the Ultraviolet technique as a clean source without pesticide, which lead to keep the storage environment without any pollution. Our findings suggest that exposure for UV may favour external treatment with particular by light environment, to preserve faba bean seeds with high quality.

Key words: Faba bean, chemical properties, physical properties, irradiation, ultraviolet, seed quality and storage

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Thirty percent of the legumes, grains and seeds are lost during the handling and the post-harvest process, which includes (transport, storage and packing) due to insects, dieses, rodents and microorganisms. That processing period begins right at the time of attainment of the physiological maturity of seeds in the field till, it was planted in the next season. Attention must be taken to preserve the germination capacity viability and vigor of the seeds[1]. Dry beans productions in Egypt were 98132 t and green bean were 283520 t in 2017 and the area harvested were 39665 and 27255 ha for dry beans and green beans, respectively[2].

Legumes (poor man's meat) play an important role in human nutrition since they are rich sources of protein, calories, minerals and vitamins and therefore can be good supplements. Faba bean (*Vicia faba* L.) is the most cultivated leguminous species in the world. Legumes are an important component of traditional diets of several regions all over the world as they are low in fat, rich in protein, dietary fiber and a variety of micronutrients and phytochemicals. Egypt is one of the largest consumers of pulses in the world[3]. Faba bean production and improving yield, quality is the major target to meet the demand of the increasing Egyptian population, since faba bean constitutes a major part of the diet of Egyptian people[4]. Sowing date and irrigation regimes are playing an vital role on water utilized and consequently on yield and quality of faba bean seeds. Faba bean (*Vicia faba* L.) is one of the oldest legume crops grown in Egypt. Now, the world's largest importer of faba bean. So, increasing faba bean production and improving yield, quality is a major target to meet the demand of the increasing Egyptian population[5]. He stated that the nutritional value of faba bean has always been traditionally attributed to its high protein content, which ranges from 27-34%, depend on genotypes[6].

The moisture-dependent physical and mechanical properties of *Jatropha curcas* were studied. By determining the physical properties and some of the mechanical properties[7]. The average length, width, thickness, thousand grain mass increased as the moisture content increased and coefficient of friction of Jatropha increased linearly against various surfaces with increased in moisture content. The bulk density and true density were found to increase, while the porosity was found to increase. Both storage methods and periods had noticeable effects on the protein contents of all parts of faba bean seeds. Crude protein content of whole seed decreased from 29.2-27.3%, 26.8 and 26.3% after storage for 3 months in Makamer, in tin cans after heating and in tin cans without heating, respectively. While, storage for 6 and 9 months resulted in gradual decreases in the protein contents of these samples to reach 23.4, 22.2 and 19.8%, respectively, after 9 months storage. These decreases in crude protein may be attributed to the activity of proteolytic enzymes[8].

Faba bean physical and mechanical attributes are so important in the design equipment for handling, drying, aeration, storing structures and processing[9]. During the first few months of storage, insect infestation and the percentage loss recorded in samples may be low but the insect infestation typically increases with time and so at the end of the season there will be a very high percentage loss in the samples[10]. However, this high loss is only applicable to the small quantity of grain remaining in the store. Although the high figures serve to demonstrate the dramatic damaging nature of the pest, they do not accurately reflect the real loss experienced by the farmer. The storage of seeds is initiated at the time of attainment of physiological maturity and maintained till the next sowing season[11]. Hence, the different stages involved in seed storage are as follows: (a) Period from physiological maturity to harvest, (b) Period from harvest to packaging, (c) Period from packaging to storing, (d) Period from storing to marketing of seeds and (e) On farm storage (Purchased seeds used for planting in the field).

The objectives of this study are:

- Study the physical, mechanical, chemical and biological properties of faba bean during the storage period to detect its quality
- Using UVC irradiation and determination the most suitable dose of UVC exposure time to conserve the faba bean during storage and extend the shelf life of seeds

MATERIALS AND METHODS

Study area: The experiments carried out in the 2017/2018 seasons, located in Giza Governorate at Agricultural Engineering Research Institute. Setup and constructed by Laser Application of Agricultural Engineering Lab., National Institute of Laser Enhanced Science, Cairo University.

Three irradiation times of UVC investigated were of 30, 60 and 90 min of exposure times were used, also and 0 min for treatment without irradiation. After exposure seeds, they were stored for 9 months, during the months of April, 2018 to January, 2019 and then 3 samples are taken

Fig. 1: Ultraviolet unit

from each treatment every 3 months and determined chemical, physical and mechanical analysis changes.

Samples and irradiation treatments: Faba bean seeds which used in this study were provided by (Field Crops Research Institute (FCRI), Agricultural Research Center (ARC). Faba bean (*Vicia faba*) of Giza716 variety quantities used 3 kg/treatment. The experimental study was included UVC Irradiation treatments have 3 exposure times of UVC radiation and sample without irradiation (control). The exposure times they were 30, 60 and 90 min for UVC treatments and 0 min for treatment without irradiation[12].

Treatments of seeds by UVC radiation were carried out in a lab scale by using 2 germicidal lamps (HRA 4384 Germany) emitting UVC at 253.7 nm and 2.5 cm diameter were placed on top of aluminum box, 60 cm length and output power of 18 Watt emitted at 253.7 nm for each one. Also, the UVC unit has timer to control in irradiation times of seeds as shown in Fig. 1.

Measurements:

- Hundred seeds were tested for mean seed dimensions the length, width, thickness of faba bean grains, using a digital-vernier caliper
- The average mass of 100-seed was calculated from 4 replicates, using a digital balance
- The maximum force to penetrate and shear compress seeds were measured by Digital force gauge in Newtons (N) was determined to represent seed hardness
- Four samples of seeds (250 g each) from each treatment to determine percentage of moisture contain, ash, protein, carbohydrates, fiber and fat were done using the procedure[1]

After the seeds were treated with UVC light, each sample was placed in a plastic bag and stored for 9 months at room temperature. Four samples are taken from each treatment every 3 months to determine the chemical, physical and mechanical analysis changes for observing the changes that occurred in faba bean quality during storage period using standard methods[13].

Statistical analysis: All experiments were carried out at different time scale to assure the authenticity of the results. Results are indicative of triplicate values expressed as Mean±SD.

RESULTS AND DISCUSSIONS

Effect of UVC irradiation on physical properties of faba bean during storage: An average of the 3 principal dimensions (length, width and thickness) of faba bean seeds was measured and indicated in the Table 1. By using UVC irradiation times (30, 60 and 90 min) and (0 min) treatment without irradiation, during storage periods of 0, 3, 6 and 9 months.

Table 1 illustrated that length dimensions decreased by increased storage periods and decreasing the irradiation times. The initial lengths at 0 months were 16.19, 16.09, 16.1 and 16.12 mm and they were 14.72, 14.79, 14.99 and 15.48 mm after 9 months for 30, 60, 90 min and 0 min (control) for UVC irradiation times, respectively.

Also, indicated that the width was increased by decreasing the storage period and increasing the irradiation times. The highest width at 0 months were 12.13 and 12.06 mm can be achieved for (0 and 90 min) and 12.02, 12.00 mm for (60 and 30 min), respectively and the lowest width were 11.33, 11.65, 11.63 and 11.55 mm for (control, 90, 60 and 30 min), respectively.

From the results introduced in Table 1, it could be observed that the thickness reduction range from 0 month to 9 months were 5.80-5.31 and 5.59-5.35 mm can be achieved for 0 and 30 min, while 5.63-5.40 mm and 5.66-5.48 mm for 60 and 90 min, respectively.

The results corresponded with authors, they studied the effect of 5 levels of moisture which ranging from 5.85-25.85% (dry basis, d.b.) on physical and mechanical properties of Jatropha. The average length, width, thickness, thousand grain mass determined by Standard methods. And found that they increased as the moisture content[11].

Authors were evaluated the physical and mechanical properties of 3 different varieties of faba bean seeds as a function of moisture content. The average length of faba bean seeds decreased from 16.46-13.55 mm, from 20.91-18.49 mm and from 22.24-20.52 mm, the width

Table 1: Effect of UVC irradiation times on principal dimensions of faba bean during storage

	UVC irradiation times (min)			
Storage period (Months)	0	30	60	90
Length (mm)				
0	16.19	16.09	16.10	16.12
3	15.56	15.62	15.75	15.86
6	15.33	15.41	15.55	15.70
9	14.72	14.79	14.99	15.48
Width (mm)				
0	12.13	12.00	12.02	12.06
3	11.69	11.66	11.71	11.83
6	11.46	11.59	11.68	11.77
9	11.33	11.55	11.63	11.65
Thickness (mm)				
0	5.80	5.59	5.63	5.66
3	5.49	5.50	5.53	5.56
6	5.44	5.44	5.47	5.50
9	5.31	5.35	5.40	5.48

Table 2: Effect of UVC irradiation times on principal dimensions of faba bean during storage

	UVC irradiation times (min)			
Storage period (Months)	0	30	60	90
Mass (mm)				
0	85.50	85.00	85.10	85.26
3	81.40	83.46	84.03	84.11
6	80.68	81.97	83.21	83.33
9	79.09	79.74	82.55	82.68
Bulk volume (cm^3)				
0	77.89	73.52	73.79	74.89
3	74.15	72.21	72.77	72.90
6	71.95	70.73	71.06	71.26
9	67.18	68.49	70.09	70.50
Bulk density (g cm^{-3})				
0	1.098	1.156	1.153	1.138
3	1.098	1.156	1.155	1.154
6	1.121	1.159	1.171	1.169
9	1.177	1.164	1.178	1.173

decreased from 13.23-10.69 mm, from 15.53-13.26 mm and from 16.82-14.99 mm, the thickness from 8.42-6.29 mm, from 9.32-7.51 mm and from 16.82-14.99 mm for 1, 2 medium and large-seeds, respectively as the moisture content decreased [12] from 26.5-9.8%.

Table 2 indicated that mass and bulk volume decreased by increasing storage periods and decreasing irradiation times. The lowest values of mass and bulk volume were (79.09 g, 67.18 cm^3 and 79.74 g, 68.49 cm^3) for (0 and 30 min). Meanwhile, they were (82.55 g, 70.09 cm^3 and 82.68 g, 70.5 cm^3) after 9 months for treatment (60 and 90 min), respectively.

From the results introduced in Table 2, it could be observed that the bulk density and true density increased by the increasing storage period and decreasing Ultraviolet irradiation time. These results compayling with authors, estimated the physical properties of pits and kernels of Hacıhaliloğlu apricots as a function of moisture content. They summarized that the weight of 1000 grains, grain volume, true density and the projected area increased with change in moisture content[14].

The physical properties of pea seed were evaluated as a function of moisture content. They found that by decreasing the moisture content from 35.08-10.06% d.b. The true and bulk densities were increased[15].

Effect of UVC times on mechanical properties of faba bean during storage

Effect of UVC irradiation times on shear force of faba bean: Figure 2a shows the Effect of UVC irradiation times on shear force of faba bean during storage periods. It was indicated that shear force was increased as the storage periods increase. Meanwhile, the shear force was found to increase by decreasing UVC irradiation times. The shear

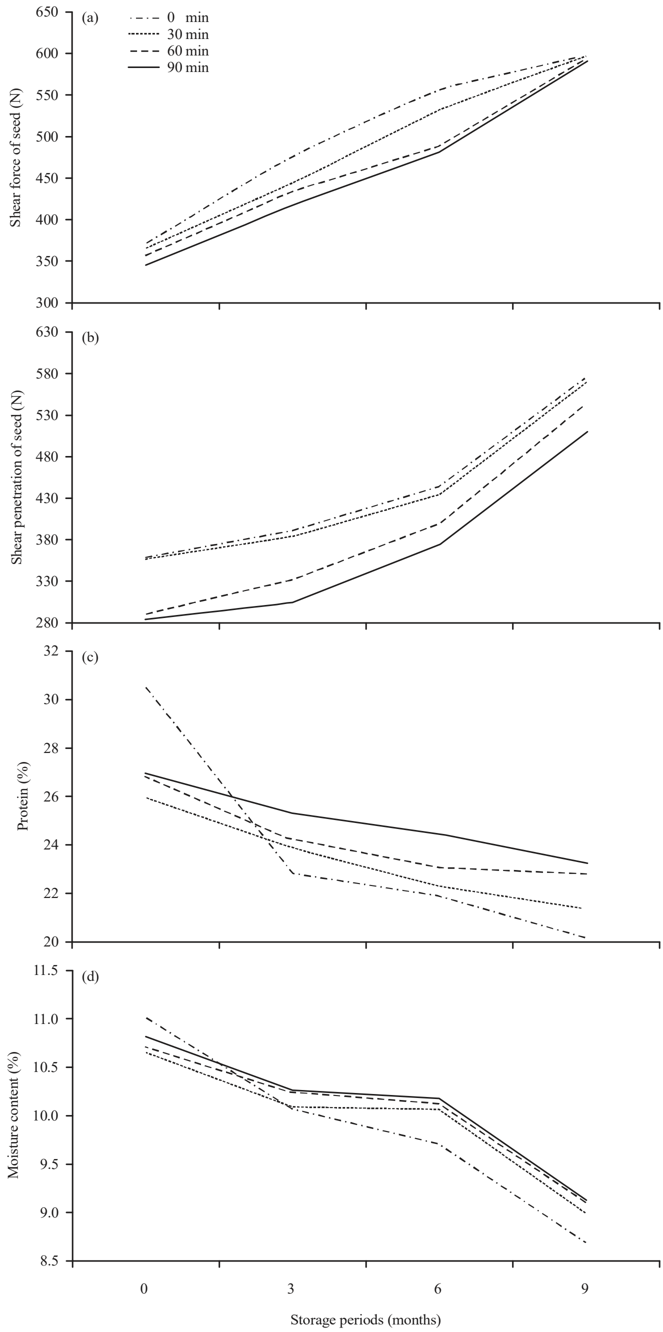

Fig. 2(a-h): Continue

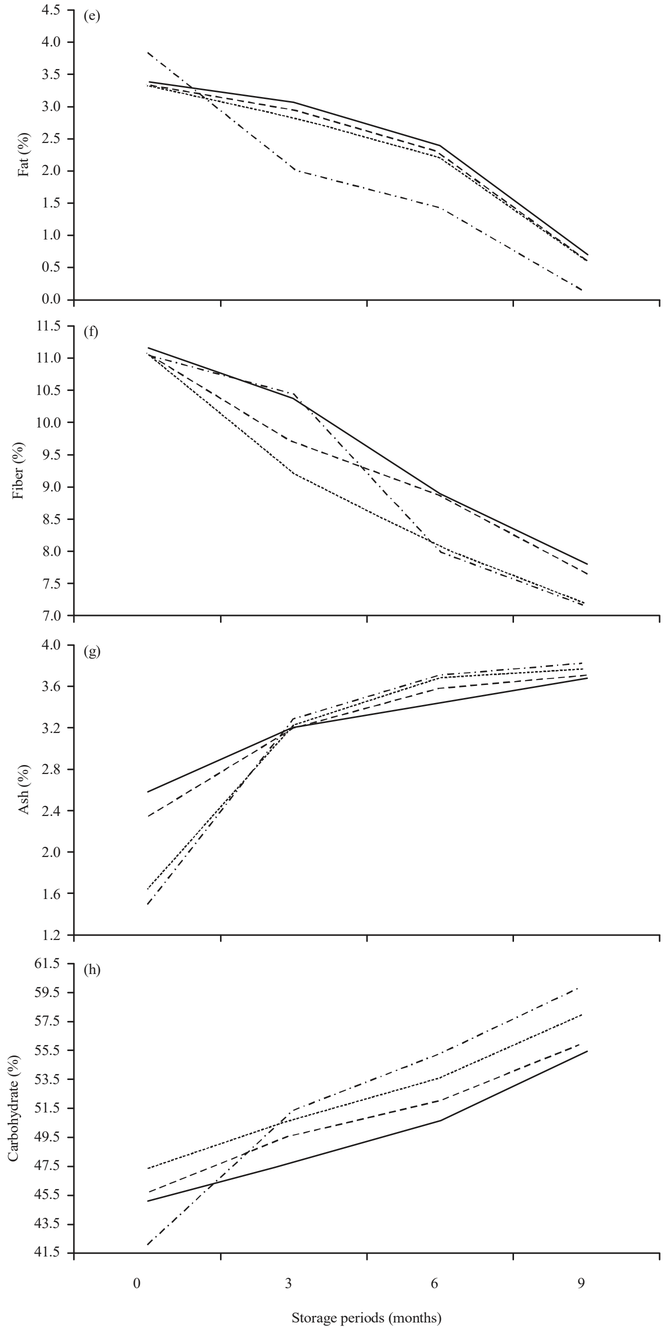

Fig. 2(a-h): Effect of UVC irradiation on (a) Shear force, (b) Penetration force, (c) Protein (%), (d) Moisture content (%), (e) Fat (%), (f) Fiber (%), (g) Ash (%) and (h) Carbohydrate (%) of faba bean during storage forces at 0 months were 371.6 and 365.8 N can be achieved for (0 and 30 min) and 357.7, 343.4 N for (60 and 90 min), respectively and the highest shear force were 597, 596.9, 593.9 and 590.9 N for (0, 30, 60 and 90 min), respectively.

Effect of UVC irradiation times on penetration force of faba bean: Figure 2b illustrated that the effect of UVC irradiation times on the penetrating force of faba bean during storage periods. It was indicated that the penetration force was increased as storage periods increased. Meanwhile, the penetration force was found to decrease with increasing UVC irradiation times. The initial penetration forces at 0 months were 358.8, 356.4, 290.9 and 283.5 N and they were 576.1, 571, 543 and 510.4 N after 9 months for 0, 30, 60 min and 90 min for UVC irradiation times, respectively this results may be related to decrease the moisture content by increasing storage times. These results are consistent with authors who reported that the hardness and toughness of pomegranate seeds decreased with increase in moisture content[16].

Effect of UVC times on chemical properties of faba bean during storage

Effect of UVC irradiation times on protein (%) of faba bean: Figure 2c shows the reduction in protein percentage at 0, 30, 60 min and 90 min of UVC irradiation times for storage periods (0, 3, 6 and 9 months). The results indicated that the highest reduction in protein percentages after 9 months, they were (20.15 and 21.36%) for (0 and 30 min) and (22.77 and 23.25%) for (60 and 90 min), respectively. The result summarized that the protein percentage has an inverse relationship with storage period and positive relationship with irradiation times.

The results were agreed with the range obtained[17], which ranged from 26.65-30.72%. Also, reported that the percentage of protein in faba beans ranged between 18-32%, which is consistent with the results obtained from the study[18]. And they were analyzed the chemical composition of the seeds of land-races maize keeps underneath totally different conditions[19]. Also, the results it had been summarized that the content of crude protein content at the top of the storage period. Authors stated that storage methods and periods had noticeable effects on the protein contents of all parts of faba bean seeds[14].

Effect of UVC irradiation times on moister (%) of faba bean: Figure 2d shows the reduction in moisture content percentage for 0, 30, 60 and 90 min of UVC irradiation times for storage periods of 0, 3, 6 and 9 months.

From the relationship between moisture content percentage for 0, 30, 60 and 90 min irradiation and storage period represented in Fig. 2d, It could be found that the moisture content percentages decreased by increasing the storage period and decrease irradiation times. The highest decrease of moisture content percentages (after 9 months) were (8.70 and 9%) can be achieved for (0 and 30 min) irradiation and (9.11 and 9.13%) for (60 and 90 min), respectively. The results agree with the range obtained[18], which ranged from 9.15-10.45%.

Effect of UVC irradiation times on fat (%) of faba bean: Figure 2e show the reduction in fat content percentage for 0, 30, 60 and 90 min of UVC irradiation times for storage periods of 0, 3, 6 and 9 months.

From Fig. 2e, it could be observed that the fat percentage decrease range (from 0-9 months) were (3.84-0.10%) and (3.32-0.60%) can be achieved for (0 and 30 min), while (3.34-0.62%) and (3.40-0.71%) for (60 and 90 min), respectively.

The results of this study are corresponding with those reported[20], working with sunflower seed concluded that oil content in the seeds declined over time regardless of storage condition. They were stated that the percentage of lipids of maize seeds decreased significantly at the end of the storage period[17], regardless of storage conditions used and they cited the explanation of the great difference in the percentage of lipids occur thanks to the increased consumption of reserve substances seeds, due to the occurrence of biochemical processes in seed mass. The results were higher than those found[18], which ranged from 1.93-2.05%. Also, reported that the fat percentage in faba beans ranged between 05-5.6%, which is agreeing with the results[19].

Effect of UVC irradiation times on fiber percent of faba bean: Figure 2f shows the reduction in fiber content percentage for 0, 30, 60 and 90 min of UVC irradiation times for storage periods of 0, 3, 6 and 9 months.

The illustrated results in Fig. 2f show the changing percentage of fiber in faba bean for treatments 0, 30, 60 and 90 min with time storage period, it could be indicated that the fiber percentage has an Inverse relationship with storage period and positive relationship with irradiation times which mean that it was decreased by increased storage period and decreasing UVC irradiation times. The decrease range from 0-9 months were (11.05-7.14%) and (11.08-7.18%) can be achieved for (0 and 30 min), while (11.11-7.65%) and (11.15-7.80%) for (60 and 90 min), respectively. The average fiber content of 12 faba bean was 6.1% it reported[21].

Effect of UVC irradiation times on ash (%) of faba bean: Figure 2g shows the reduction in ash content percentage for 0, 30, 60 and 90 min of UVC irradiation times for storage periods of 0, 3, 6 and 9 months.

Figure 2 g, it could be indicated that the ash content increased by increased the storage period and decreasing irradiation times. The highest values (9months) were (3.84, 3.77, 3.71, 3.68%) can be achieved (0, 30, 60 min) and 90 min, respectively. Similar results were obtained[17], who stated that during the storage period, the metabolic activity of seeds and associated microorganisms consume the organic matter. So, increasing the intake of organic material the ashes will raise. While, they found the average Ash for 12 faba bean cultivar [21] was 3.2%. The results were agreed with those found[18], which ranged from 3-3.35%.

Effect of UVC irradiation times on carbohydrate (%) of faba bean: Figure 2h shows the reduction in carbohydrate percentage for 0, 30, 60 and 90 min of UVC irradiation times for storage periods of 0, 3, 6 and 9 months.

The results illustrated in Fig. 2f show the carbohydrate percentage which increased by increasing the storage time and decreasing irradiation times. The increase range from 0-9 months were (42.1-60.07%) and (47.36-58.09%) can be achieved for (0 and 30 min), while (45.67-56.14%) and (45.1-55.43%) for (60 and 90 min), respectively.

They were stated that there is an inverse relationship between carbohydrates and with protein and lipid fractions during storage[17]. The carbohydrate percentage of faba beans ranged from 55-63% was reported[19]. They obtained 58-62% for carbohydrates of faba beans[18].

Figure 2c-h indicated that the effect of irradiation treatment with storage period on chemical properties of faba bean. Results show that protein, moisture content, fat and fiber increased. While the ash and carbohydrate was decreased with increase storage time. That may be occurring because of the chemical characteristics of degradation and/or of a request of its constituents during storage. The applying of UV radiation can be extend shelf life of faba bean grains, therefore the recommendations are to provide the treatments for others grain to decrease losses of grains during storage.

CONCLUSION

The different quality properties of faba bean after UVC irradiation time found to be:

- The main dimensions, mass and bulk volume and true decreased by increasing the storage period and decreasing UVC exposure time. Meanwhile, the bulk and true density increase by increasing the storage period and decreasing UVC exposure time
- The shear and penetration force was increased as the storage periods increase and decreasing UVC exposure time
- That protein, content, fat and fiber increased. While the ash, moisture and carbohydrate was decreased with increase storage time and decreasing UVC exposure time

SIGNIFICANCE STATEMENT

The present research focusing on preserve the faba bean grains using irradiation by ultraviolet in different doses to extend shelf life of grains. Selecting the suitable doses to use irradiation process in order to preserve the faba bean grains for long time. The study of physical , mechanical and chemical properties in grains ensures the food safety. The idea of irradiation faba bean grains has the potential to provide a improve grain quality. The present research opens up vistas to carry further research in preserve grains to reduce grain losses and increase shelf life of grains in a novel way with low cost.

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LASER RADIATION EFFECT ON FABA BEAN QUALITY DURING STORAGE

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Abstract

The main purpose of the present study the effect of laser exposure time on faba bean seed quality by study the properties (physical, mechanical and chemical) of faba bean during storage periods. A laser light source was Helium-Neon laser with wavelength 632.8nm and power 8m W. Three exposure time of laser irradiation were of 15, 30 and 45min and 0min for treatment without irradiation, on the Faba bean Giza 716 variety. After exposure seeds, they were stored for nine months and then three samples are taken from each treatment every three months and determined chemical, physical and mechanical analysis changes to observe the changes that occur during storage period. Result showed that the main dimensions, mass and bulk volume, true volume, protein, moisture content, fat and fiber were decreased by decreasing laser exposure time and increasing the storage period. Meanwhile, the bulk, true density, shear, penetration force, ash and carbohydrate were increased by increasing storage period and by decreasing laser exposure time.

Key words : *Vicia faba*, irradiation, physical, mechanical and chemical.

Introduction

Nearly thirty percent of the legumes; grains and seeds are lost during the handling and post harvest process, which includes (transport, storage and packing) due to insects, dieses, rodents and microorganisms. That processing period begins right at the time of attainment of the physiological maturity of seeds in the field till it was planted in the next season. Attention must be taken to preserve the germination capacity viability and vigor of the seeds (Parimala *et al.*, 2013).

Dry beans productions in Egypt were 98132 tonnes and green bean were 283520 tonnes in 2017 and the area harvested were 39665 and 27255 ha for dry beans and green beans, respectively (FAO/ faostat, 2019).

Legumes are a good source of vitamins (thiamine, riboflavin, niacin, vitamin B6, and folic acid) and certain minerals such as (Ca, Fe, Cu, Zn, P, K and Mg) and are a good source of polyunsaturated fatty acids. Different studies reported that the large consumption of legumes may be due to protect from diseases such as cancer, diabetes, osteoporosis, and cardiovascular diseases, among others (Annor *et al*., 2014).

Faba bean grain has a protein content of 24- 30%, depending on the variety. Just like other legumes, faba beans accumulate a lot of proteins through seed development. The amino acid compositions of the protein in faba beans are quite similar to other legumes and are characterized by a generally good nutritional quality with the exception of low sulphur amino acid and tryptophan concentration. In a diet, it is easily compensated for by eating it with grains (Ehsanzamir, 2018).

According to Altuntas and Yýldýz (2007) determined the effect of moisture content on some physical and mechanical properties behavior under compression load of faba bean grains. The average length, width, thickness, geometric mean diameter, unit mass of grain, sphericity, thousand grain mass, the grain volume, true density, porosity, surface area and angle of repose were

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increased as the moisture content increased. Meanwhile, the bulk density was found to decrease with increasing the moisture content.

Both storage methods and periods had noticeable effects on the protein contents of all parts of Faba bean seeds. Crude protein content of whole seed decreased from 29.2% to 27.3, 26.8 and 26.3% after storage for three months in Makamer, in tin cans after heating and in tin cans without heating, respectively. While, storage for six and nine months resulted in gradual decreases in the protein contents of these samples to reach 23.4, 22.2 and 19.8%, respectively, after nine months storage. These decreases in crude protein may be attributed to the activity of proteolytic enzymes (El-Refai *et al*., 1988).

Faba bean physical and mechanical attributes are so important in the design equipment for handling, drying, aeration, storing structures and processing (Shoughy and Amer, 2006).

Laser light has many applications in agriculture, but there is still much work to provide scientific evidence of its potential use as an alternative for the control of diseases originating within the seed, particularly for fungi that area unit internal. Even laser treatment has been reported to be effective, although since laser beams is narrow and the whole surface of the seed should be evenly exposed for good effect it is of limited practical interest (Sharma *et al*., 2015).

The stored product pests gain access to the grain storage from the standing crop in the field to various stages of grain processing and storage. Although, regarding one thousand species of insects are related to hold on merchandise in numerous elements of the globe, a few pests are considered as pests causing severe damage to the stored grains. The hold on grain insect pests are often classified on the premise of their feeding behavior as internal and external feeder or as major and minor pests supported the severity of damage, they cause (Srivastava and Sabtharishi, 2016).

The objectives of this study are :

- Study the physical, mechanical and chemical properties of faba bean during storage period.
- Using laser rays to conserve faba bean during storage period.
- Determine the most suitable dose of laser radiations to conserve the faba bean during storage.

Materials and Methods

Sample preparation

Faba bean seeds which used in this study were provided by Field Crops Research Institute, ARC. Faba bean (*Vicia faba*) Giza 716 variety quantities used 3kg/ treatment. The experimental study was including laser Irradiation treatments have three exposure times of Laser radiation and sample without irradiation (control). The exposure times they were 15, 30 and 45 min for laser treatments and 0 min for treatment without irradiation.

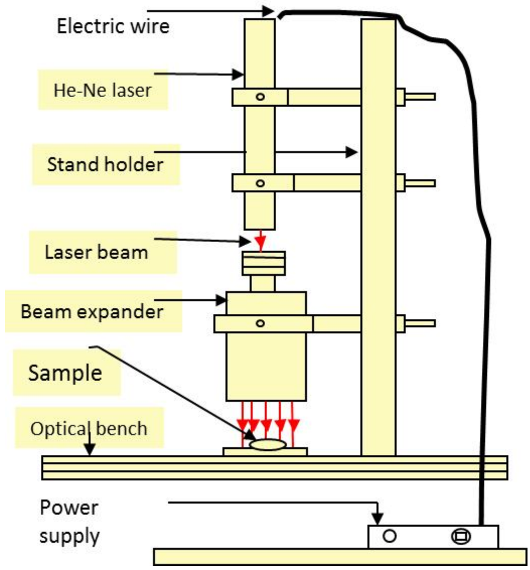

Fig. 1 : Setup of laser.

Laser setup

As a source of radiation, was used a Helium-Neon gas laser (He-Ne) with an output power of 8mW and 632.8nm wavelength. It was consisted of the laser source, holders and beam expander. The Opto –electronic apparatus is shown in fig. 1.

Physical and mechanical characteristics

- Hundred Seeds were tested for mean seed dimensions the length, width, thickness of Faba bean grains, using a digital-vernier caliper.
- The average mass of 100-seed was calculated from 4 replicates, using a digital balance.
- The maximum force to penetrate and shear compress seeds were measured by Digital force gauge in Newtons (N) was determined to represent seed hardness.

Chemical characteristics

Four samples of seeds (250g each) from each treatment to determine percentage of moisture contain, ash, protein, carbohydrates, fiber and fat were done using the A.O.A.C. (2000) procedure.

After seeds were treated by Laser beam, each sample was placed in a plastic bag and stored for nine months at room temperature. Four samples are taken from each treatment every three months to determined chemical, Physical and mechanical analysis changes for observing the changes that occurred in faba bean quality during storage period.

Statistic analysis

A specialist statistical program (SPSS, Ver. 20) used to analyze the data to study the significant of deference between means of dependent and independent variables for faba bean seed by ANOVA and least significant difference (LSD).

Results and Discussion

Effect of laser exposure time on physical properties of faba bean during storage periods

Effect of laser exposure time on Principal Dimensions of faba bean : An average of the three principal dimensions (length, width and thickness) of faba bean seeds were indicated in figs. 2, 3 and 4 by using laser exposure time (15, 30 and 45min) and (0 min) treatment without irradiation, during storage periods of 0, 3, 6 and 9 months.

Fig. 2 indicated that length dimensions decreased by increased storage periods. The initial lengths at 0 months were 16.17, 16.18, 16.19 and 16.19mm and they were 15.6, 15.69, 15.74 and 14.72mm after 9months for 15, 30, 45min and 0min (control) for laser exposure time, respectively.

Fig. 3 illustrated that the width was increased by decreasing the storage time. The highest width at 0 months were 12.13 and 12.13mm can be achieved for (0 and 45min) and 12.1, 12.09mm for (30 and 15min), respectively and the lowest width were 11.33, 11.96, 11.78 and 11.67mm for (control, 45, 30 and 15min), respectively.

From the results introduced in fig. 4, it could be observed that the thickness reduction range from (0 month) to (9 months) were (5.73 – 5.46mm) and (5.76-5.47 mm) can be achieved for (15 and 30min), while (5.79-5.62mm) and (5.80-5.31mm) for (45 and 0min), respectively. Similar results of increased in the physical properties with moisture content are reported by Tavakoli *et al*. (2009), who evaluated the effect of four levels of moisture content ranging from 6.92 to 21.19% d.b. on some physical properties behaviour under compression load of soybean grains. Increased the average width, length, thickness, geometric mean diameter, arithmetic,

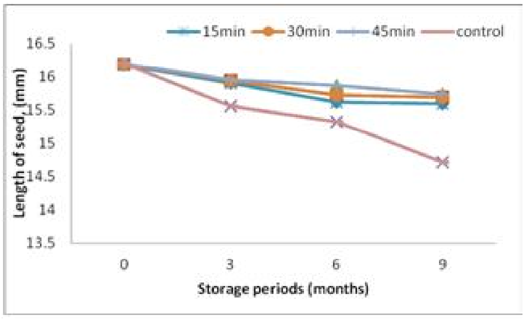

Fig. 2 : Effect of laser exposure time on length of faba bean seeds.

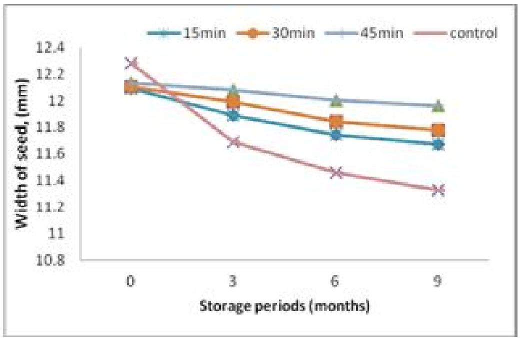

Fig. 3 : Effect of laser exposure time on width of faba bean seeds.

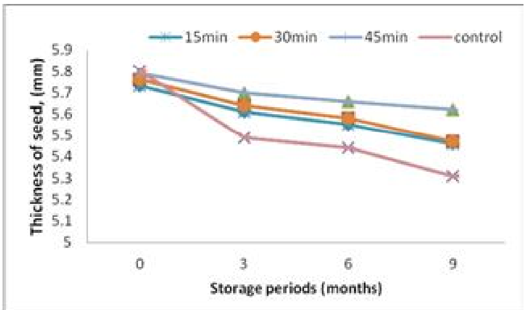

Fig. 4 : Effect of laser exposure time on thickness of faba bean seeds.

angle of repose surface area and thousand grain mass by increasing moisture content from 6.92 to 21.19%.

Shoughy and Amer (2006) evaluated the physical and mechanical properties of three different varieties of faba bean seeds as a function of moisture content. The average length of faba bean seeds decreased from 16.46 to 13.55mm, from 20.91 to 18.49mm and from 22.24 to 20.52mm; the width decreased from 13.23 to 10.69mm, from 15.53 to 13.26mm and from 16.82 to 14.99mm; the thickness from 8.42 to 6.29mm, from 9.32 to 7.51 mm

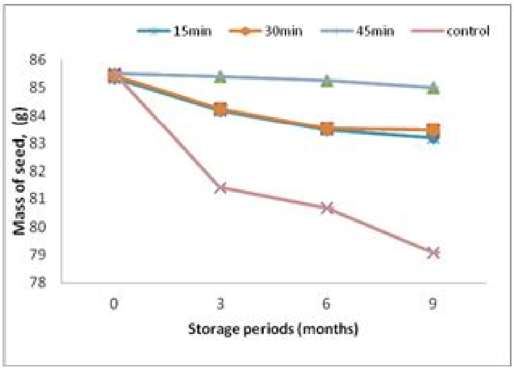

Fig. 5 : Effect of laser exposure time on mass of faba bean seeds.

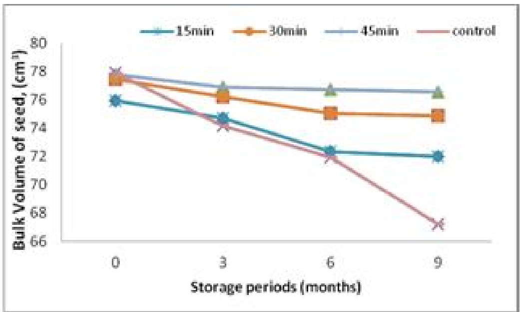

Fig. 6 : Effect of laser exposure time on bulk volume of faba bean.

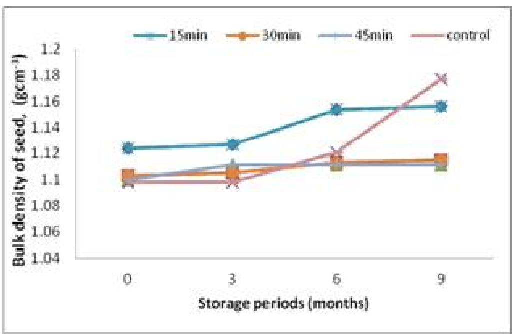

Fig. 7 : Effect of laser exposure time on bulk density of faba bean seeds.

and from 16.82 to 14.99mm for medium1, medium2 and large-seeds, respectively as the moisture content decreased from 26.5 to 9.8%. Altuntas and Yýldýz (2007) studied the effect of moisture content on some physical properties and mechanical behavior for faba bean grains. The average width, length and thickness ranged from 13.66 to 12.54mm, 19.77 to 18.40mm and 8.03 to 7.00 mm, respectively. And the unit mass of grain, grain volume, sphericity, thousand grain mass, angle of repose and true

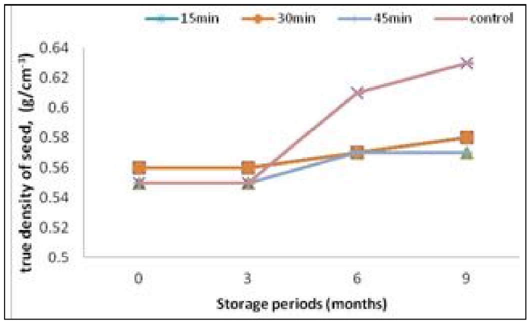

Fig. 8 : Effect of laser exposure time on true density of faba bean seeds.

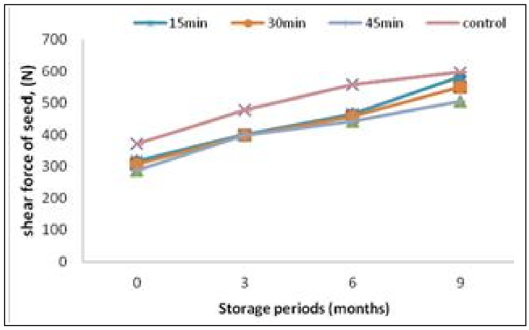

Fig. 9 : Effect of laser exposure time on shear of Faba bean seeds.

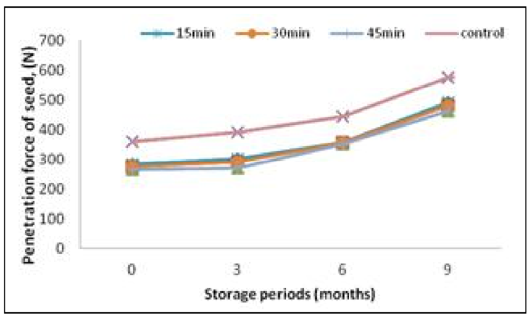

Fig. 10 : Effect of laser exposure time on penetration of faba bean seeds.

density of faba bean grains decreased from 1.301 to 1.147g, 1.099 to 0.998 Cm^3, 1332.67 to 1140.15g, 1206.21 to 1151.33 kgm^{-3} respectively as the moisture content decreased from 25.08% to 9.89% d.b.

Effect of laser exposure time on Mass , Volume and density of faba bean : Fig. 5 indicated that mass decreased by increasing storage periods. The lowest values of mass were (79.09 and 83.18g) for (0 and 15min). While they were (83.46 and 85g) after 9months for treatment (30, 45min), respectively.

Figs. 6 and 7, they were indicated that bulk volume and true volume decreased by increasing storage periods. The lowest values after 9 month were (67.18 and 126 cm^3) and (71.96 and 144 cm^3) for (0 and 15min). While they were (74.87 and 145cm^3) and (76.53 and 149 cm^3) after 9 months for treatment (30, 45min), respectively.

From the results introduced in figs. 5, 6, 7 and 8, it could be observed that the bulk density and true density increased by the increasing storage period.

Shoughy and Amer (2006) evaluated the physical and mechanical properties of three different varieties of faba bean seeds as a function of moisture content in the range of 9.8 to 26.5% (dry basis, d.b.). The volume of seed and thousand seed mass were linearly increased. While, the bulk and true densities have a negative relationship with moisture content. Altuntas and Yýldýz (2007) determined the effect of moisture content on some physical properties and mechanical behavior for faba bean grains. They found that as the moisture content decreased from 25.08% to 9.89%d.b., the bulk density was found to increase from 381.6 to 419.59kgm^{-3}. Yalçýn *et al*. (2007) the physical properties of pea seed were evaluated as a function of moisture content. They found that by decreasing the moisture content from 35.08 to 10.06%d.b. The true and bulk densities were increased.

Effect of laser exposure time on mechanical properties of faba bean during storage periods

Effect of laser exposure time on shear force of faba bean : Fig. 9 shows the Effect of laser exposure time on shear force of faba bean during storage periods. It was indicated that shear force was increased as the storage periods increase. Meanwhile, the shear force was found to decrease with increasing laser exposure time. The initial shear force at 0 months were 318.3, 308.8, 287.0 and 371.6N and they were 582.1, 550.4, 503.9 and 597.0N after 9months for 15, 30, 45min and 0min (control) for laser exposure time, respectively.

Effect of laser exposure time on Penetration force of faba bean : Fig. 10 illustrated that the effect of laser exposure time on the penetration force of faba bean during storage periods. It was indicated that the Penetration force was increased as storage periods increased. Meanwhile, the Penetration force was found to decrease with increasing laser exposure time. The highest Penetration force at 0 months were 576.1 and 490.1N can be achieved for (0 and 15min), and 480.9, 463.3N for (30 and 45min), respectively, and the lowest Penetration force were 358.8, 264.1, 273.9 and 282.7N for (control, 45, 30 and 15min), respectively. These results are consistent with Kingsly *et al*. (2006) who reported that the hardness and toughness of pomegranate seeds decreased with increase in moisture content.

Effect of laser exposure time on chemical properties of faba bean during storage periods

Effect of laser exposure time on protein percent of faba bean : Fig. 11 shows the reduction in protein percentage at 15, 30, 45 min and 0min of laser exposure time for storage periods (0, 3, 6 and 9 months). The results indicated that the highest reduction in protein percentages at (after 9 months) were (23.22 and 22.78%) for (45 and 30 min) and (21.92 and 20.15%) for (15 and 0 min), respectively.

The results were agreed with the range obtained by Abeer *et al*. (2013), which ranged from 26.65 to 30.72%. Likewise, Boghdady *et al*. (2017) also reported that the percentage of protein in faba beans ranged between 18-32%, which is consistent with the results obtained from the study. And Gezer *et al*. (2003) found that Protein content was 29.63%. While Al-Nouri and Siddiqi (1982) state the range of protein percentage between 24.2 - 29.2% for 12 faba bean cultivar.

Effect of laser exposure time on moister percent of faba bean : Fig. 12 show the reduction in Moisture content percentage for 15, 30, 45 min and 0min laser exposure time for storage time (0, 3, 6 and 9 months). The relationship between reduction in moisture content percentage for 45, 30, 15 and 0 min irradiation and storage period represented in fig. 12. It could be found that the moisture content percentages decreased by increasing storage period. The highest reduction (after 9 months) were (9.20 and 9.17%) can be achieved for (45, 30min) irradiation and (9.14 and 8.70%) for (15, 0min), respectively. The results agree with the range obtained by Abeer *et al*. (2013), which ranged from 9.15 to 10.45%.

Effect of laser exposure time on fat percent of faba bean : Fig. 13 shows the reduction in fat percentage for 15, 30, 45min and 0min of laser exposure time for storage periods (0, 3, 6 and 9 months).

From the results introduced in fig. 13, it could be observed that the fat percentage decrease range from 0 to 9 months were (3.69 - 2.00%) and (3.52- 1.95%) can be achieved for (45 and 30 min), while (3.50 - 1.73%) and (3.84 - 1.73%) for (15 and 0min), respectively. The results of this study are equal to those reported by Abreu *et al*. (2013), working with sunflower seed concluded that oil content in the seeds declined over time regardless of storage condition. Stefanello *et al*. (2015) stated that the percentage of lipids of maize seeds decreased

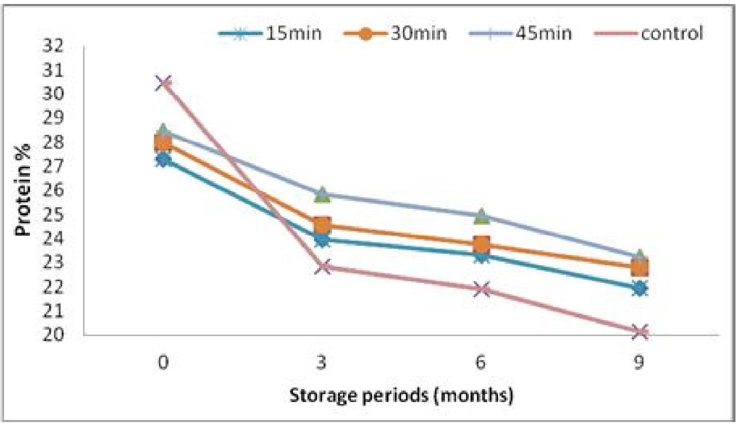

Fig. 11 : Effect of laser exposure time on protein percentage of Faba bean during storage time.

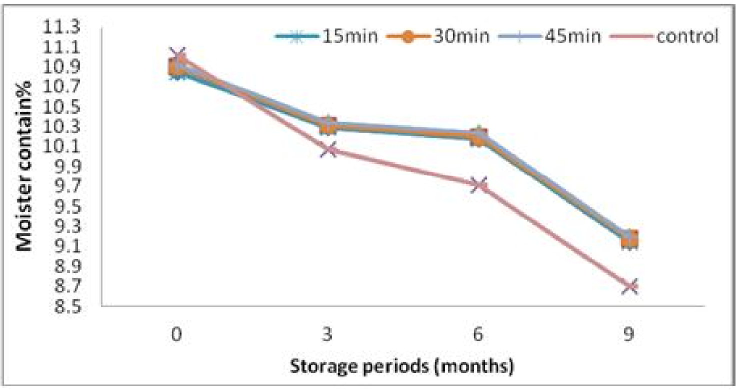

Fig. 12 : Effect of laser exposure time on moisture percentage of Faba bean during storage time.

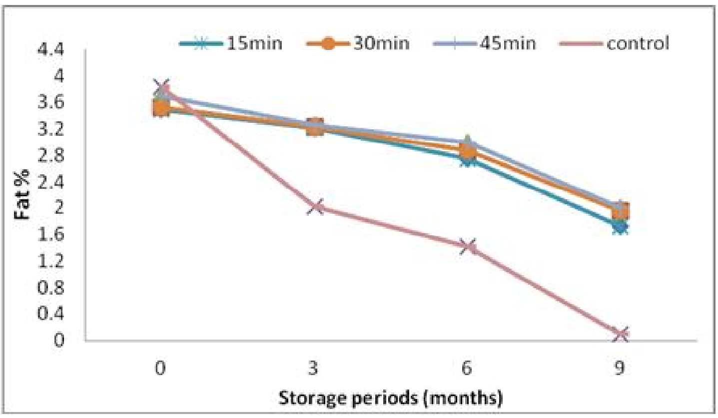

Fig. 13 : Effect of laser exposure time on fat percentage of Faba bean during storage time.

significantly at the end of the storage period, regardless of storage conditions used, And they cited the explanation of the great difference in the percentage of lipids occur thanks to the increased consumption of reserve substances seeds, due to the occurrence of biochemical processes in seed mass.

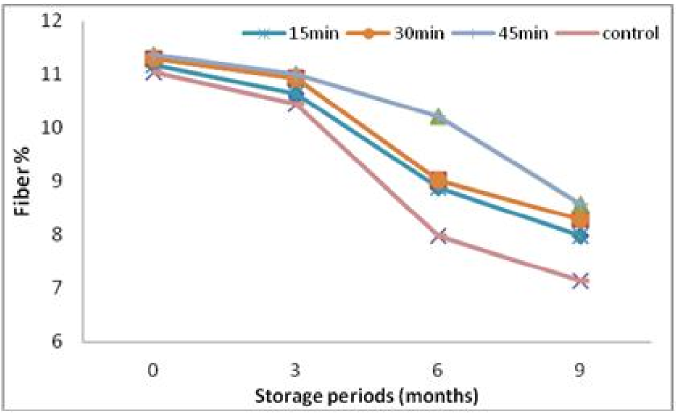

Fig. 14 : Effect of laser exposure time on fiber percentage of Faba bean during storage time.

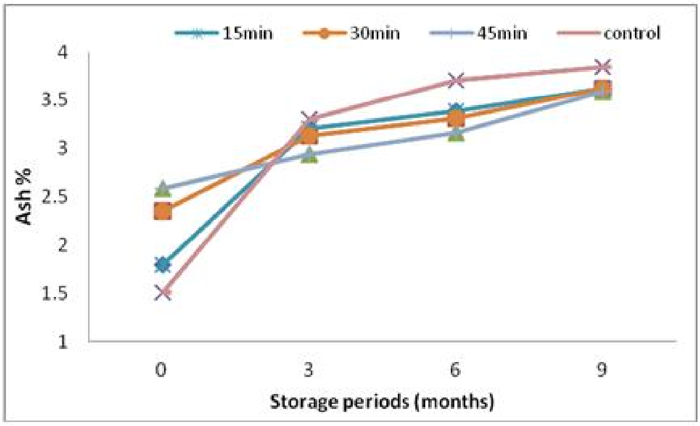

Fig. 15 : Effect of laser exposure time on ash percentage of Faba bean during storage time.

Effect of laser exposure time on Fiber percent of faba bean : Fig. 14 show the reduction in fiber content percentage for 15, 30, 45 and 0min of laser exposure time for storage periods (0, 3, 6 and 9 months). The results presented in fig. 14 show the change in faba bean fiber percentage for treatments 45, 30, 15 and 0min with time storage period, it could be indicated that the fiber percentage decreased by increased storage period. The highest decreased after 9months was (8.58 and 8.30 %) can be achieved for (45, 30min) and (7.99 and 7.14%) for treatments (15, 0min), respectively. The average Fiber content of twelve faba bean cultivar was 6.1% it reported by Al-nouri and Siddiqi (1982).

Effect of laser exposure time on ash percent of faba bean : Fig. 15 shows the reduction in ash content percentage for 15, 30, 45 and 0min of laser exposure time for storage periods (0, 3, 6 and 9 months).

Fig. 15 indicated that the ash content increased by increased the storage period. The highest values (9months) were (3.95, 3.62%) can be achieved (45, 30 min) and (3.62, 3.84%) for (15, 0) min, respectively. Similar results were obtained by Stefanello *et al*. (2015) that is during the storage period, the metabolic activity of seeds and associated microorganisms consume the organic matter metabolizing it to carbon dioxide, without changing the mineral composition. Consequently, increasing the intake of organic material the ashes will raise. While Al-nouri and Siddiqi (1982) found the average Ash for twelve faba bean cultivar was 3.2%.

Effect of laser exposure time on carbohydrate percent of faba bean : Fig. 16 shows the reduction in carbohydrate percentage for 15, 30, 45 min and 0min of laser exposure time for storage periods (0, 3, 6 and 9 months).

Fig. 16 indicated that the carbohydrate percentage increased by increasing the storage time. The high

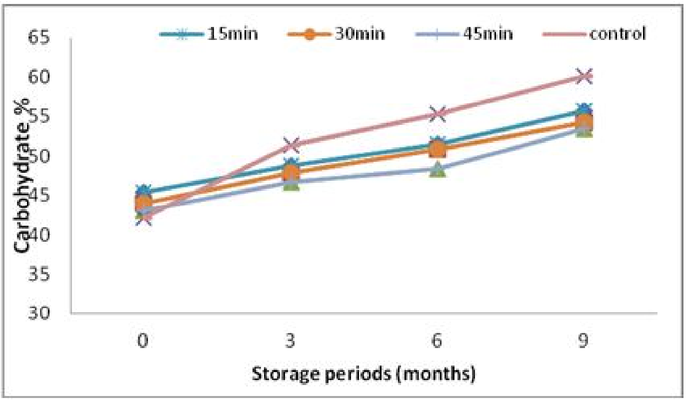

Fig. 16 : Effect of laser exposure time on carbohydrate percentage of Faba bean during storage time.

Table 1 : Least significant difference (LSD) results.

Items	Average of laser exposure time (min)			
	0	15	30	45
Length (mm)	15.45	15.82*	15.88*	15.94*
Width (mm)	11.65	11.85*	11.93*	12.04*
Thickness (mm)	5.51	5.59	5.61*	5.69*
Mass (g)	81.67	84.04*	84.16*	85.29*
Bulk Volume (cm^3)	72.79	73.73	75.90*	76.98*
Bulk density (g/cm^3)	1.12	1.14*	1.11*	1.11*
True density (g/cm^3)	0.59	0.57*	0.57*	0.56*
Shear (N)	500.85	441.68	428.90*	408.13*
Penetration (N)	442.73	357.85*	350.50*	336.95*
Fat %	1.85	2.80*	2.89*	2.99*

* The mean difference is significant at the 0.05 level.

carbohydrate after 9 month were (60.07 and 55.60%) can be achieved for (0 and 15min) and (54.18 and 53.4%) for (30 and 15min), respectively. Stefanello *et al*. (2015) stated that the increase in the percentage of carbohydrates is related to the decrease between the protein and lipid fractions during storage. The carbohydrates content of faba beans ranged from 55-63% was reported by Boghdady *et al*. (2017). Abeer *et al*. (2013) obtained 58 to 62.25.8% for carbohydrates of faba beans.

Figs. 11, 12, 13, 14, 15 and 16 indicated that the effect of irradiation treatment with storage time on chemical properties of faba bean. Results show that protein, moisture content, fat, and fiber increased. While the ash and carbohydrate was decreased with increase storage time. That may be occurring because of the chemical characteristics of degradation and/or of a request of its constituents during storage.

Statistic analysis

ANOVA test outlined that the correlation between laser treatment and physical and mechanical properties and fat percentage of faba beans seeds is worth mentioning because calculated F is significant, meanwhile, for the rest chemical properties were none statistically significant at the 0.05 level. Which means that laser treatment preserve the quality of the physical and mechanical properties of bean seeds and does not effect the chemical content of the seeds.

From table 1, the single most conspicuous observation to emerge from the data comparison was no significant differences between 30min and 45min for faba bean seeds for all indicators.

Conclusion

The different quality properties of faba bean after Laser irradiation time found to be :

The main dimensions, mass and bulk volume and true decreased by increasing the storage period and decreasing laser exposure time. Meanwhile, the bulk and true density increase by increasing the storage period, and increasing laser exposure time. While the shear and Penetration force was increased as the storage periods increase, and decreasing laser exposure time. Main whiles that protein, content, fat and fiber increased. While the ash, moisture and carbohydrate was decreased with increase storage time and decreasing laser exposure time.

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8. ARABIC SUMMARY

٢- تاثير الاشعة فوق بنفسجية علي الخصائص الميكانيكية لبذور الفول البلدي:

لقدتلاحظ زيادة قوة القص والاختراق مع زيادة فترات التخزين ، وانخفاض زمن التشعيع باستخدام لاشعة الاشعة فوق بنفسجية ، حيث كانت أقل زيادة في قوة القص والاختراق في المعاملة ٩٠ دقيقة والتي سجلت ٥٩٠,٩ ، ٥١٠,٤ نيوتن لقوة القص والاختراق.

٣- تاثير الاشعة فوق بنفسجية علي الخصائص الكيميائية لبذور الفول البلدي:

أ- أظهرت النتيجة أن نسبة البروتين ومحتوى الرطوبة و نسبة الدهون و نسبة الألياف قد انخفضت بانخفاض زمن التعرض لاشعة فوق بنفسجية وزيادة فترة التخزين. حيث كان أقل انخفاض في نسبة البروتين ومحتوى الرطوبة و نسبة الدهون و نسبة الألياف في المعاملة ٩٠ دقيقة والتي سجلت ٢٣,٢٥ ، ٩,١٣ ، ٠,٧١ ، ٧,٨٠ ٪ للبروتين ، ومحتوى الرطوبة ، و نسبة الدهون ، و نسبة الألياف ، على الترتيب.

ب - في حين وجدت زيادة في نسبة كلا من الرماد والكربوهيدرات بزيادة فترة التخزين وانخفاض زمن التشعيع باستخدام الاشعة فوق بنفسجية. و كانت أقل زيادة في المعاملة ٩٠ دقيقة والتي سجلت ٣,٦٨ ، ٥٥,٤٣ للرماد والكربوهيدرات ، على الترتيب.

٤- تاثير الاشعة فوق بنفسجية علي الخصائص البيولوجية لبذور الفول البلدي:

وجد ان على عد ميكروبي (cfu / g) كان بعد ٩ أشهر من التخزين في المعاملة بدون تشعيع كان (٤.٥*١٠^٦) بينما كان اقل عد ميكروبي كان في المعاملة بالتشعيع لمدة ٩٠ دقيقة حيث سجلت ١٨٠٠.

٥- تاثير الاشعة فوق بنفسجية علي الخصائص اللونية لبذور الفول البلدي:

أظهرت النتيجة أن قيمة معاملتي الاضاءة L و b* (red-green) تنخفض بينما تزداد a* (yellow-blue) بزيادة وقت التخزين. حيث كانت قيمة L، a*، b* في بداية التجربة هي ٤٧ و ٧ و ٣٦ ، وبينما كانت تلك القيم (٢٥،١٩،٢٤) بعد ٩ أشهر للمعاملة ٩٠ دقيقة .

أهم التوصيات و الدراسات المستقبلية : -

- استخدام التكنولوجيات الحديثة مثل اشعة الليزر والأشعة فوق البنفسجية كعلاجات للتخزين الآمن للبذور.

- تصميم وتصنيع جهاز تشعيع للاستخدام أثناء النقل وتداول البذور.

- استخدام تقنية الليزر أو الأشعة فوق البنفسجية في تشعيع البذورقبل تخزينها.

ب- في حين زادت نسبة كلا من الرماد والكربوهيدرات بزيادة فترة التخزين وانخفاض زمن التعرض لاشعة الليزر. وحيث كانت أقل زيادة في المعاملة ٤٥ دقيقة والتي سجلت ٣,٥٩ ، ٥٣,٤١ للرماد والكربوهيدرات ، على الترتيب.

٤- تاثير الليزر علي الخصائص البيولوجية لبذور الفول البلدي:

لقد تبين من النتائج ان على عد ميكروبي (cfu / g) كان بعد ٩ أشهر من التخزين للمعاملة بدون تشعيع كان (٤.٥*١٠^٦) بينما كان اقل عد ميكروبي كان في المعاملة بالتشعيع لمدة ٤٥ دقيقة حيث سجلت ١٠٠.

٥- تاثير أشعة الليزر علي الخصائص اللونية لبذور الفول البلدي:

أظهرت النتيجة أن قيمة معاملتي الاضاءة L و b* (red-green) تنخفض بينما تزداد a* (yellow-blue) بزيادة وقت التخزين. حيث كانت قيمة L، a*، b* في بداية التجربة هي ٤٧ و ٧ و ٣٦ ، وبينما كانت تلك القيم (٢٩،١٤،٣٧) بعد ٩ أشهر للمعاملة ٤٥ دقيقة.

<u>ثانيا: التشعيع باشعة الفوق بنفسجية.</u>

١- تاثير الاشعة فوق بنفسجية علي الخصائص الفيزيائية لبذور الفول البلدي:

أ- كان هناك اختلاف في الأبعاد الرئيسية (الطول والعرض والسمك) لبذور الفول ، حيث انخفضت الابعاد بزيادة فترة التخزين وبانخفاض زمن التشعيع بالاشعة فوق بنفسجية(UVC) ، حيث كان أدنى انخفاض في الأبعاد الرئيسية في المعاملة ٩٠ دقيقة والتي سجلت ١٥,٤٨ ، ١١,٦٥ ، ٥,٤٨ مم للطول والعرض والسمك ، على الترتيب.

ب- وجد هناك اختلاف في الكتلة والحجم الظاهري والحقيقي لبذور الفول ، حيث انخفضت تلك الخصائص بزيادة فترة التخزين و بانخفاض زمن التشعيع بالاشعة فوق بنفسجية(UVC)، حيث كان أدنى انخفاض في الكتلة والحجم الظاهري و الحقيقي في المعاملة ٩٠ دقيقة والتي سجلت ٨٢,٦٨جرام ، ٧٠,٥سم^٣ ، ١٤٠سم^٣ للكتلة والحجم الظاهري والحقيقي ، على الترتيب.

جـ- تلاحظ زيادة الكثافة الظاهرية و الحقيقية بزيادة فترة التخزين وانخفاض زمن التعرض التشعيع باستخدام الاشعة فوق بنفسجية ، حيث كانت أعلى زيادة في الكثافة الظاهرية والكثافة الحقيقية في المعاملة ٩٠ دقيقة حيث سجلت ١,١٧٣ و ٠,٦٣ سم ٣ للكثافة الظاهرية والحقيقية ، على الترتيب.

كل ثلاثة اشهر وذلك لدراسة التغيرات الكميائية والفيزيائية و الميكانيكية والبيولوجية و اللونية التي حدثت في البذور اثناء فترة التخزين. وقد أمكن تلخيص النتائج التي تم الحصول عليها علي النحو التالي:-

أولا: التشعيع باشعة الليزر.

١- تاثير الليزر علي الخصائص الفزيائية لبذور الفول البلدي:

أ- وجد اختلاف في قياس الأبعاد الرئيسية (الطول والعرض والسمك) لبذور الفول ، حيث انخفضت مقاييس الابعاد بزيادة فترة التخزين وبانخفاض زمن التعرض لاشعة الليزر ، حيث كان أدنى انخفاض في الأبعاد الرئيسية في المعاملة ٤٥ دقيقة والتي سجلت ١٥,٧٤ ، ١١,٩٦ ، ٥,٦٢ مم للطول والعرض والسمك ، على الترتيب.

ب- كان هناك اختلاف في الكتلة والحجم الظاهري والحقيقي لبذور الفول ، حيث انخفضت تلك الخصائص بزيادة فترة التخزين وانخفاض زمن التعرض لاشعة الليزر ، حيث كان أدنى انخفاض في الكتلة والحجم الظاهري والحقيقي في المعاملة ٤٥ دقيقة والتي سجلت ٨٥جرام ، ٧٦.٥٣سم^{٣} ، ١٤٩سم^{٣} للكتلة والحجم الظاهري والحقيقي ، على الترتيب.

جـ- تلاحظ زيادة الكثافة الظاهرية و الحقيقية بزيادة فترة التخزين وبانخفاض ازمنة التعرض لشعة الليزر ، حيث كانت أعلى زيادة في الكثافة الظاهرية والكثافة الحقيقية في المعاملة ٤٥ دقيقة حيث سجلت ١,١٧٧ ، ٠,٦٣ سم^{٣} للكثافة الظاهرية والحقيقية ، على الترتيب.

٢- تاثير الليزر علي الخصائص الميكانيكية لبذور الفول البلدي:

لقد زادت قوة القص والاختراق مع زيادة فترات التخزين ، وانخفاض زمن التعرض لاشعة الليزر ، حيث كانت أقل زيادة في قوة القص والاختراق في المعاملة ٤٥ دقيقة والتي سجلت ٥٠٣,٩ ، ٤٦٣.٣نيوتن لقوة القص والاختراق ، على الترتيب.

٣- تاثير أشعة الليزر علي الخصائص الكميائية لبذور الفول البلدي:

أ- أظهرت النتيجة أن نسبة البروتين ومحتوى الرطوبة و نسبة الدهون و نسبة الألياف قد انخفضت بانخفاض زمن التعرض لاشعة الليزر وزيادة فترة التخزين. حيث كان أقل انخفاض في نسبة البروتين ومحتوى الرطوبة و نسبة الدهون و نسبة الألياف في المعاملة ٤٥ دقيقة والتي سجلت ٢٣,٢٢ ، ٩,٢٠ ، ٢ و ٨,٥٨ ٪ للبروتين ، ومحتوى الرطوبة ، و نسبة الدهون ، و نسبة الألياف ، على الترتيب.

الملخص العربي

التخزين الآمن للفول البلدي باستخدام تقنيات الليزر و الاشعة فوق البنفسجية

الفول البلدي يعتبر الوجبة الأساسية والتي لا تستغني الأسرة المصرية عنهيومياً على مائدة الطعام وخاصة في وجبة السحور الرمضانية، نظراً لأسعارها المعقولة وفوائدها الغذائية المتعددة. وفقا للدراسات فإن الفول غني بالبروتينات والفيتامينات والأملاح المعدنية مثل الحديد والفوسفور ، وبحسب بيانات عام ٢٠١٨ ، فإن استهلاك المصريين للفول سنويًا يتراوح بين ٦٥٠ إلى ٧٥٠ ألف طن سنويًا ، ويبلغ حجم الاستهلاك اليومي ٢٥٠٠ طن ، بينما يصل استهلاك المصريين من الفول خلال يوم واحد في شهر رمضان إلى ١٠ آلاف طن.

يفقد ما يقرب من ٣٠٪ من البقوليات أثناء التداول وعمليات ما بعد الحصاد، وتعد حماية المنتجات الزراعية المخزنة من هجوم الحشراتأمر ًا ضروريًا لتوفير إمدادات آمنة وثابتة من الأغذية عالية الجودة للحفاظ على قدرة إنبات والحيوية ونشاط البذور.

مما يعني أن دراسة الخواص الكميائية والفيزيائية و الميكانيكية والبيولوجية و اللونية للفول البلدي لها أهمية كبيرة في تصميم معدات التداول و المحافظة علي جودة الذور خلال فترة التخزبن.

بدات التجارب في فصل الربيع (مايو ٢٠١٨) في محافظة الجيزة حيث تم اعداد و بناء نظام ووحدة التشعيع بالاشعة فوق البنفسجية بمعهد بحوث الهندسة الزراعية- مركز البحوث الزراعية- الجيزة- بينما تم التشعيع باستخدام اشعة الليزر في المعهد القومي لعلوم الليزر - جامعه القاهرة.

كان مصدر ضوء الليزر المستخدم هو الهليوم نيون بطول موجي ٦٣٢.٨نانوميتر وطاقة ٨ ملي وات. حيث تم إستخدم أربعة أزمنة للتعرض لاشعة الليزر و هي ١٥، ٣٠، ٤٥ دقيقة وكذلك معاملة (دون تشعيع) علي صنف جيزة ٧١٦. كما استخدم مصدر للاشعة فوق البنفسجية (UVC) ذوطول موجي ٢٥٣.٧ نانوميتر وطاقة ٣٦وات حيث تم إستخدام ثلاث أزمنة للتشعيع بالاشعة فوق البنفسجية وهي ٦٠،٣٠، ٩٠دقيقة وكذلك معاملة (دون تشعيع)، وبعد تعرض البذور للتشعيع تم تخزينها لمدة تسعة اشهر ، وتم اخذ اربع عينات من كل معاملة

التخزين الآمن للفول البلدي باستخدام تقنيات الليزر و الاشعة فوق البنفسجية

رسالة علمية مقدمة من

الطالبة/ ماهينور عربي ابراهيم ابراهيم

قسم تطبيقات الليزر في القياسات والكيمياء الضوئية والزراعية

تخصص تطبيقات الليزر في التكنولوجيا الحيوية والزراعة

المعهد القومي لعلوم الليزر

جامعة القاهرة

لجنة الإشراف:

أ.د/ حلمي السيد حسن محمد.

أستاذ تطبيقات الليزر في الهندسة الزراعية – المعهد القومي لعلوم الليزر – جامعة القاهرة.

أ.د/ أحمد الراعي إمام سليمان

أستاذ الهندسة الزراعية – كليةالزراعة – جامعة القاهرة.

أ.د/ عبد الرحمن عبد الرؤوف عبد الرحمن.

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2021

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للحصول على درجة دكتوراة الفلسفة

من قسم تطبيقات الليزر في القياسات والكيمياء الضوئية والزراعة

تخصص تطبيقات الليزر في التكنولوجيا الحيوية والزراعة

مقدمة من

الطالبة/ ماهينور عربي ابراهيم ابراهيم

بكالوريوس في العلوم الزراعية (هندسة زراعية) جامعة القاهرة - 2003

ماجستيرفي العلوم الزراعية (هندسة زراعية) جامعة عين شمس - 2015

المعهد القومي لعلوم الليزر

جامعة القاهرة

2021